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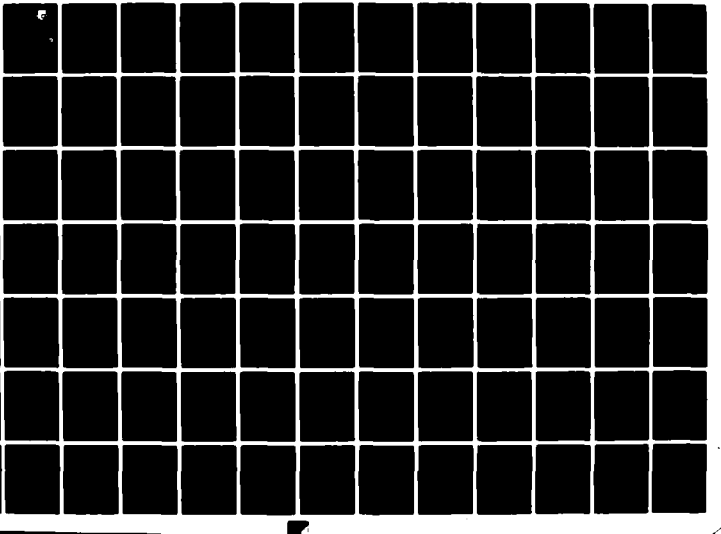

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VOLUME II

LATERAL FLYING QUALITIES OF HIGHLY AUGMENTED FIGHTER AIRCRAFT

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FLIGHT DYNAMICS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This in-flight simulation experiment, using the USAF NT-33 variable stability aircraft operated by Calspan, was undertaken to generate lateral-directional flying qualities data applicable to highly augmented fighter aircraft. In particular, the effects of time delay and prefilter lag in the lateral flight control system were studied for representative Flight Phase Category A and C tasks. The combined effects of these elements as well as the effects of nonlinear command gain and high Dutch roll

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damping were also evaluated. Tasks included were actual target tracking, air refueling and precision landing as well as special Head-Up Display (HUD) tracking tasks. Results indicated that a properly designed HUD bank angle tracking task is a valid flying qualities evaluation task. Data show that lateral flying qualities are very sensitive to control system time delay and very short values of roll mode time constant typically result in poor lateral flying qualities. Excellent separation of the data into flying qualities levels is achieved for the Category A task data using time domain equivalent systems parameters. An optimum equivalent time constant value of 0.5 sec is indicated by the data; sensitivity to equivalent time delay is a minimum at this value. Volume I contains the body of the report, while Volume II consists of the Appendices.

FOREWORD

This report is separated into two volumes. Volume I contains the body of the report covering the experiment design, presentation of data, and discussion of the results. Details of the experiment, its mechanization and additional analyses and correlation of the data have been compiled in a series of appendices, contained herein, as Volume II.

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LIST OF ILLUSTRATIONS (CONCLUDED)

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LIST OF SYMBOLS

$e^{-\tau s}$	Time delay (sec), Laplace notation
F_{as}	Roll control stick force, positive right (lb)
F_{es}	Pitch control stick force, positive aft (lb)
F_{rp}	Rudder pedal control force, positive right (lb)
g	Acceleration of gravity (ft/sec^2)
h	Altitude (ft)
I_x	Moment of inertia about X axis (ft-lb sec^2)
I_y	Moment of inertia about Y axis (ft-lb sec^2)
I_z	Moment of inertia about Z axis (ft-lb sec^2)
I_{xz}	Product of inertia (ft-lb sec^2)
L	Rolling moment (ft-lb)
$L_{(\ )}$	$= \frac{1}{I_x} \frac{\partial L}{\partial (\ )}$
L'_i	$= \left(1 - \frac{I_{xz}^2}{I_x I_z}\right)^{-1} \left(L_i + \frac{I_{xz}}{I_x} N_i\right)$
N	Yawing moment (ft-lb)
$N_{(\ )}$	$= \frac{1}{I_z} \frac{\partial N}{\partial (\ )}$
N'_i	$= \left(1 - \frac{I_{xz}^2}{I_x I_z}\right)^{-1} \left(N_i + \frac{I_{xz}}{I_z} L_i\right)$
n_y	Side acceleration (g's)
$N_{Y_{EP}}$	Side acceleration at pilot's reference eye point (g's)
n_z	Normal acceleration (g's)
n_z/α	Normal acceleration per unit angle of attack (g's/rad)
p	Roll rate (deg/sec or rad/sec)
p_{ss}	Steady-state roll rate (deg/sec)
$\dot{p}_{max}$	Maximum roll acceleration (deg/sec^2)
$\dot{p}_{max}/F_{AS}$	Maximum roll acceleration per unit lateral stick force (deg/sec^2/lb)
r	Yaw rate (deg/sec)
s	Laplace operator (sec^{-1})
v	Incremental velocity along reference Y-axis (fps)

V	True velocity (ft/sec)
$\overline{x}$	Mean value
Y	Side force (lb)
$Y_{(\ )}$	$= \frac{1}{mV} \frac{\partial Y}{\partial (\ )}$
x,y,z	Stability axes (i.e., a right hand orthogonal body axis system with origin at the c.g., the z axis in the plane of symmetry and the x-axis aligned with the relative wind at zero sideslip trimmed flight
α	Angle of attack (deg)
β	Angle of sideslip (deg)
$\delta_{a,e,r}$	Aileron, elevator, and rudder deflections (deg)
δ_{AS}	Aileron control stick deflection at grip (in)
δ_{ES}	Elevator control stick deflection at grip (in)
δ_{RP}	Rudder pedal deflection (in)
$\zeta_{a,e,r}$	Aileron, elevator and rudder actuator damping ratio
ζ_{DR}	Dutch-roll damping ratio
ζ_{p}	Phugoid damping ratio
ζ_{sp}	Short period damping ratio
ζ_{ϕ}	Damping ratio of numerator ϕ/F_{AS} transfer function
θ	Pitch attitude (deg)
σ	Standard deviation
τ	Additional roll control system transport time delay, $e^{-\tau s}$ (sec)
τ_{E}, τ_{Eff}	$e^{-\tau_E s}$, equivalent, effective time delay (sec)
τ_{R}	Roll mode time constant (sec)
$\tau_{R_E}, \tau_{R_{Eff}}$	Equivalent, effective roll mode time constant (sec)
τ_{s}	Spiral mode time constant (sec)
τ_{1}	Numerator time constant of roll control system lead/lag prefilter (sec)
τ_{2}	Denominator time constant of roll control system lag prefilter (sec)
$\tau_{\theta_{1,2}}$	Airframe lead time constants in θ/F_{ES} transfer function (sec)
ϕ	Bank angle (deg)
ϕ_{c}	Commanded bank angle (deg)

LIST OF SYMBOLS (CONT'D)

ϕ_e	Bank angle error, $\phi_e = \phi_c - \phi$ (deg)
$\lvert\phi/\beta\rvert_{DR}$	Absolute value of controls-fixed roll to sideslip ratio at ω_{DR}
ψ	Heading angle (deg)
$\omega_{a,e,r}$	Undamped natural frequency of aileron, elevator, and rudder actuators
ω_{DR}	Undamped natural frequency of Dutch-roll (rad/sec)
ω_p	Longitudinal phugoid undamped natural frequency (rad/sec)
ω_{sp}	Longitudinal short period undamped natural frequency (rad/sec)
ω_ϕ	Undamped natural frequency of numerator quadratic in ϕ/F_{AS} transfer function numerator (rad/sec)
$(\ )_T$	Referenced to trim flight condition
$(\dot{\ })$	Rate of change of ( ) with time (( )/sec)

LIST OF ABBREVIATIONS

AFWAL	Air Force Wright Aeronautical Laboratories
AGL	Above Ground Level
AR	Air Refueling task
c.g.	center of gravity
DEFT	Display Evaluation Flight Test
deg	degrees
EP	Evaluation Pilot
ESP	Equivalent System Program
FFT	Fast Fourier Transformation
fps	feet per second
ft	feet
HUD	Head-Up-Display; also, Head-up-display-based Bank angle and Heading angle Tracking Tasks
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
in	inches
KIAS	Knots, Indicated Airspeed
kts	knots
LA	Landing and Approach task
LATHOS	Lateral Higher Order System
lb	pounds
mil	milliradian
MOA	Military Operating Area
msec	millisec
MSL	Mean Sea Level
NADC	Naval Air Development Center
NATC	Naval Air Test Center
PIO	Pilot-induced Oscillation
PR	Pilot Rating
rad	radian
rms	root-mean-square
sec	seconds

LIST OF ABBREVIATIONS (CONCLUDED)

SP	Safety Pilot
SPR	Safety Pilot Rating
TAS	True Airspeed
Tgt	Target
TR	Formation and Gun Tracking Task
USAF	United States Air Force
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VSS	Variable Stability System

APPENDIX A

SUMMARY OF PILOT RATING RESULTS

A complete summary of the results of the evaluations which were considered valid by the authors is given in Tables A-1 and A-2 for the Flight Phase Category A and C tasks respectively; 151 Category A evaluations and 43 Category C evaluations are included. Both the evaluation pilot rating and the safety pilot rating are included in the table. Of the original 214 evaluations performed 20 were rejected for reasons which are given in the pilot comment summaries for each evaluation. (See Appendix B and C for more information).

Table A-3 of this appendix presents a summary of the equivalent time history parameters for each configuration. This analysis as well as the definitions for each of the parameters listed in Table A-3 is presented in Section 6. The time domain equivalent values of roll mode time constant ($\tau_{R_{Eff}}$) and time delay (τ_{Eff}) were calculated via a computer program from the the nominal configuration dynamics.

TABLE A - 1

SUMMARY OF RESULTS - FLIGHT PHASE CATEGORY "A" TASKS

CONFIG. NO.	TASK	PILOT	FLIGHT	EVAL. NO.	τ_R	P_{ss}/F_{AS}	PREFILTER τ_2	PREFILTER τ_1	TIME DELAY[1]	PR/SPR
1-2	TR	B	2506	165	0.80	10	0.025			5/5
	HUD	B	2512	207						7/7
1-3	TR	B	2478	41	0.80	18	0.025			3/3
1-3T1	TR	B	2503	146	0.80	18	0.025		.075	7/5
1-3T2	TR	B	2496	112	0.80	18	0.025		.105	8/9
1-3F2	TR	B	2498	122	0.80	18	0.167			6/6
1-3T0F7	HUD	P	2507	171	0.80	18	0.025	0.05	.055	5/5
2-2	TR	G	2476	34	0.45	10	0.025			5/2
	TR	P	2477	38						3/3
	TR	B	2505	157						3/2
	AR	G	2481	50						3/2
	AR	B	2484	58						2/3
	HUD	B	2471	16						4/4
2-2T1	TR	B	2479	45	0.45	10	0.025		.075	2/2
	AR	G	2481	53						2/1
2-2T2	TR	B	2500	132	0.45	10	0.025		.105	6/5
	TR	B	2508	177						5/6
2-2T3	TR	G	2475	31	0.45	10	0.025		.125	7/6
	AR	G	2481	52						7/7
2-2T4	TR	B	2469	8	0.45	10	0.025		.225	8/8
	TR	P	2477	40						8/7
	HUD	B	2471	15						9/8
2-2F1	TR	B	2494	102	0.45	10	0.10			3/3
2-2F3	TR	B	2500	133	0.45	10	0.30			6/6
2-2T1F1	TR	B	2496	114	0.45	10	0.10		.075	5/6
	TR	P	2497	118						7/6
2-3	TR	P	2493	99	0.45	18	0.025			2/2
	TR	P	2497	117						3/3

TABLE A - 1 (CONT'D)

SUMMARY OF RESULTS - FLIGHT PHASE CATEGORY "A" TASKS

CONFIG. NO.	TASK	PILOT	FLIGHT	EVAL. NO.	τ_R	P_{ss}/F_{AC}	PREFILTER τ_2	PREFILTER τ_1	TIME DELAY[1]	PR/SPR
2-3	TR	B	2508	180						2/1
	AR	G	2482	56						3/3
	AR	B	2484	59						4/3
2-3T1	TR	P	2495	108	0.45	18	0.025		.075	6/4
	TR	B	2498	123						3/3
	TR	B	2508	178						4/4
	AR	B	2485	65						4/4
2-3T2	TR	B	2492	95	0.45	18	0.025		.105	5/5
	TR	P	2493	100						6/4
	HUD	P	2511	198						4½/5
2-3T3	TR	B	2505	158	0.45	18	0.025		.125	9/8
	AR	G	2488	85						8/8
2-3F1	AR	G	2487	78	0.45	18	0.10			3/3
	AR	G	2488	83						3/3
	HUD	B	2471	14						5/5
2-3F2	TR	B	2503	148	0.45	18	0.167			4/3
	AR	B	2486	70						3/3
2-3F3	TR	P	2498	43	0.45	18	0.30			8/8
	HUD	P	2490	89	0.45	18				6/6
2-3T1F1	TR	B	2496	113	0.45	18	0.10		.075	6/7
2-3T2F7	HUD	P	2507	172	0.45	18	0.025	0.05	.105	4/4
2-3D2	TR	B	2508	181	0.45	18	0.025			3/2
2-4	TR	G	2475	30	0.45	25	0.025			3/2
	TR	P	2477	39						5/4
	TR	B	2498	124						3/3
	HUD	B	2471	17						2/3
	HUD	P	2490	90						3/3
2-4T1	TR	B	2479	46	0.45	25	0.025		.075	5/5
2-4T2	AR	G	2482	57	0.45	25	0.025		.105	6/6
	AR	B	2484	61						6/5

TABLE A - 1 (CONT'D)

SUMMARY OF RESULTS - FLIGHT PHASE CATEGORY "A" TASKS

CONFIG. NO.	TASK	PILOT	FLIGHT	EVAL. NO.	τ_R	ν_{sc}/F_{AS}	PREFILTER τ_2	PREFILTER τ_1	TIME DELAY[1]	PR/SPR
2-4T2	HUD	B	2512	208						7/6
2-4T3	TR	G	2476	35	0.45	25	0.025		.125	9/8
2-4F1	AR	B	2485	63	0.45	25	0.10			2/3
	AR	B	2486	71						2/2
	HUD	B	3471	18						4/4
2-4F2	TR	B	2508	179	0.45	25	0.167			3/3
	AR	B	2485	64						2/2
	AR	B	2486	72						1/2
	HUD	P	2511	199						3/3
2-4F3	TR	B	2492	94	0.45	25	0.30			7/7
	AR	B	2484	60						8/8
	HUD	P	2507	173						7/6
2-4T1F1	TR	P	2495	109	0.45	25	0.10		.075	7/5
2-4T2F1	TR	B	2494	103	0.45	25	0.10		.105	9/9
2-4N2	TR	B	2500	134	0.45	25	0.025			4/4
2-4T2N2	TR	B	2503	147	0.45	25	0.025		.105	5/5
	TR	B	2505	160						5/5
2-4F1N2	TR	B	2509	186	0.45	25	0.10			5/5
2-4T1F1N2	TR	B	2505	159	0.45	25	0.10		.075	8/8
3-2	TR	B	2478	42	0.25	10	0.025			4/3
	TR	P	2495	111						3/3
	AR	G	2481	51						4/4
3-3	TR	B	2478	44	0.25	18	0.025			5/4
	TR	B	2494	104						5/5
	TR	P	2497	119						4/4
	AR	G	2488	86						7/7
	HUD	P	2511	200						2/3
3-3T2	TR	B	2496	115	0.25	25	0.025		.105	7/7
3-3T3	AR	B	2486	73	0.25	25	0.025		.125	7/7

TABLE A - 1 (CONT'D)

SUMMARY OF RESULTS - FLIGHT PHASE CATEGORY "A" TASKS

CONFIG. NO.	TASK	PILOT	FLIGHT	EVAL. NO.	τ_R	P_{BO}/F_{AO}	PREFILTER τ_2	PREFILTER τ_1	TIME DELAY[1]	PR/SPR
3-3F1	TR	G	2475	32	0.25	18	0.10			5/4½
	AR	G	2481	55						4/5
3-3F3	TR	B	2485	66	0.25	18	0.30			6/6
	HUD	B	2500	135						7/7
3-3F4	TR	B	2503	149	0.25	18	0.50			5½/6
	AR	G	2487	80						5/6
3-3F5	HUD	P	2511	201	0.25	18	1.0			7/7
3-3T1F1	TR	B	2498	125	0.25	18	0.10		.075	7/7
3-3D2	TR	B	2505	162	0.25	18	0.025			2/2
	TR	B	2508	182						2/2
3-3T1D2	HUD	P	2511*	203	0.25	18	0.025		.075	3/2
	HUD	P	2511**	205						2/2
3-3T2D2	TR	B	2508	183	0.25	18	0.025		.105	6/6
3-4	TR	G	2475	33	0.25	25	0.025			7/7
	TR	B	2509	191						4/4
	AR	G	2481	54						8/8
	HUD	B	2500	136						4/4
	HUD	B	2512	212						5/5
3-4T2	TR	P	2493	101	0.25	25	0.025		.105	7/7
3-4F1	TR	B	2479	49	0.25	25	0.10			3/3
	AR	B	2486	75						2/3
3-4F3	AR	B	2486	74	0.25	25	0.30			4/4
3-4F4	AR	G	2487	81	0.25	25	0.5			4/4
	HUD	B	2512	213						8/7
3-4F5	TR	B	2492	97	0.25	25	1.0			8/8
3-4T1F1	TR	B	2506	170	0.25	25	0.10		.075	7/7
3-4T2F1	HUD	B	2494	107	0.25	25	0.10		.105	8/8
3-4N1	TR	G	2476	37	0.25	25	0.025			7/6
	AR	B	2485	69						5/5
3-4N2	TR	B	2505	161	0.25	25	0.025			4½/4

*Both bank and heading tracking task.
**Bank angle tracking task only.

TABLE A - 1 (CONT'D)

SUMMARY OF RESULTS - FLIGHT PHASE CATEGORY "A" TASKS

CONFIG. NO.	TASK	PILOT	FLIGHT	EVAL. NO.	τ_R	p_{ss}/F_{AS}	PREFILTER τ_2	PREFILTER τ_1	TIME DELAY[1]	PR/SPR
3-4N2	HUD	B	2500	137	0.25	25				3/3
3-4F1N2	HUD	B	2512	211	0.25	25	0.10			5/5
3-4T1F1N2	TR	B	2506	169	0.25	25	0.10		.075	8/8
3-4T1F4D2	HUD	P	2511	204	0.25	25	0.5		.075	8/7
5-2	TR	B	2465	3	0.15	10	0.025			7/7
	TR	B	2470	12						7/7
5-2T1	AR	B	2485	67	0.15	10	0.025		.075	7/7
5-2T3	TR	B	2470	13	0.15	10	0.025		.125	8/8
5-2F1	TR	B	2496	116	0.15	10	0.10			5/5
	AR	B	2486	77						7/6
5-2F2	TR	B	2498	127	0.15	10	0.167			5/5
5-2F3	TR	B	2509	187	0.15	10	0.30			6/6
5-2T0F6	TR	B	2494	105	0.15	10	0.40	0.15	.055	4/3
5-2T1F6	TR	B	2506	167	0.15	10	0.40	0.15	.075	6/6
5-2T1F1	HUD	B	2494	106	0.15	10	0.10		.075	7/7
5-3	TR	G	2476	36	0.15	18	0.025			7/7
	TR	B	2509	190						*4/4
	HUD	B	2508	184						7/5
	HUD	B	2512	210						*4/4
5-3T1	TR	B	2509	189	0.15	18	0.025		.075	7/7
5-3T2	AR	G	2488	88	0.15	18	0.025		.105	8/8
5-3F1	AR	B	2484	62	0.15	18	0.10			3/3
5-3F3	TR	B	2509	188	0.15	18	0.30			4/4
	AR	B	2485	68						2/4
	AR	B	2486	76						3/3
5-3F5	AR	G	2488	87	0.15	18	1.0			7/6
5-3T1F6	TR	P	2495	110	0.15	18	0.40	0.15	.075	7/5
5-3T1F1	TR	P	2497	120	0.15	18	0.10		.075	7/7
5-3T2F1	AR	G	2487	82	0.15	18	0.10		.105	8/8

*PR=7 used, see pilot comment sheet for details and Section 5 for discussion.

TABLE A - 1 (CONCLUDED)

SUMMARY OF RESULTS - FLIGHT PHASE CATEGORY "A" TASKS

CONFIG. NO.	TASK	PILOT	FLIGHT	EVAL. NO.	τ_R	P_{ss}/P_{AJ}	PREFILTER τ_2	PREFILTER τ_1	TIME DELAY[1]	PR/SPR
5-3N2	TR	B	2506	168	0.15	18	0.025			4½/4
5-3N3	HUD	P	2507	174	0.15	18	0.025			4/4
5-3T1N3	HUD	P	2507	175	0.15	18	0.025		.075	2/3
	HUD	P	2511	202						4½/6
5-3F1D2	TR	B	2505	164	0.15	18	0.10			3/3

[1] Time delay values are the amount of equivalent time delay added to each configuration. Equivalent time delay is used to represent this delay because the time delay network is comprised of a pure digital delay plus two analog prefilters. See Appendix G for a complete description of the time delay network.

TABLE A - 2

SUMMARY OF RESULTS - FLIGHT PHASE CATEGORY "C" TASKS

CONFIG. NO.	TASK	PILOT	FLIGHT	EVAL. NO.	τ_R	p_{ss}/F_{AS}	PREFILTER τ_2	PREFILTER τ_1	TIME DELAY[1]	PR/SPR
L1-1	LA	P	2472	19	0.80	5	0.025			3/3
		P	2510	192						6/6
L1-2	LA	B	2468	4	0.80	10	0.025			2/3
		P	2501	138						4/3
		P	2502	141						3/3
L1-2T1	LA	B	2474	26	0.80	10	0.025		.075	2/2
	LA	P	2510	193						4/4
L1-2T2	LA	P	2499	129	0.80	10	0.025		.105	6/6
L1-2T3	LA	B	2473	22	0.80	10	0.025		.125	8/8
L1-2T4	LA	P	2472	20	0.80	10	0.025		.225	8/8
L1-2F1	LA	P	2499	128	0.80	10	0.10			5/3
		P	2504	151						4/3
L1-2F2	LA	P	2502	140	0.80	10	0.167			8/8
L1-2T1F1	LA	P	2504	150	0.80	10	0.10		.075	6/3
L2-1	LA	B	2468	5	0.45	5	0.025			2/2
L2-1T1	LA	P	2504	152	0.45	5	0.025		.075	4/3
L2-1T2	LA	P	2501	139	0.45	5	0.025		.105	5/5
L2-1T4	LA	B	2474	27	0.45	5	0.025		.225	9/8
L2-1F1	LA	B	2473	23	0.45	5	0.10			3/2
L2-1F3	LA	P	2502	142	0.45	5	0.30			4/5
	LA	P	2510	194						3/3
L2-2	LA	B	2474	28	0.45	10	0.025			2/2
	LA	P	2504	153						2/3
L2-2F1	LA	P	2502	143	0.45	10	0.10			2/3
L2-2F2	LA	P	2510	195	0.45	10	0.167			3/3
L2-2F3	LA	B	2473	24	0.45	10	0.30			8/7
L2-2D1	LA	P	2502	144	0.45	10	0.025			2/2
	LA	P	2510	196						2/2

TABLE A - 2 (CONCLUDED)

SUMMARY OF RESULTS - FLIGHT PHASE CATEGORY "C" TASKS

CONFIG. NO.	TASK	PILOT	FLIGHT	EVAL. NO.	τ_R	p_{ss}/F_{AS}	PREFILTER τ_2	PREFILTER τ_1	TIME DELAY[1]	PR/SPR
L3-1	LA	P	2490	92	0.25	5	0.025			4/4
	LA	P	2499	130						3/4
L3-1N2	LA	P	2504	154	0.25	5	0.025			4/2
L3-1D1	LA	P	2504	155	0.25	5	0.025			2/2
	LA	P	2507	176						4/3
L3-2	LA	B	2468	6	0.25	10	0.025			2/2
L3-2T2	LA	P	2490	93	0.25	10	0.025		.105	5/5
L4-1	LA	P	2472	21	0.20	5	0.025			4½/5
	LA	B	2473	25						5/5
L4-1T2	LA	P	2504	156	0.20	5	0.025		.105	3/3
	LA	P	2511	206						3/3
L4-1F1	LA	P	2499	131	0.20	5	0.10			3/2
L4-1N1	LA	B	2474	29	0.20	5	0.025			4/4
L4-1N2†	LA	P	2510	197	0.20	7†	0.025			2/2
L4-1N4	LA	P	2502	145	0.20	5	0.025			4½/2

[1] Time delay values are the amount of equivalent time delay added to each configuration. Equivalent time delay is used to represent this delay because the time delay network is comprised of a pure digital delay plus two analog prefilters. See Appendix G for a complete description of the time time delay network.

† Command gain increased for this evaluation: $|p/F_{AS}|_{ss}$ = 7 deg/sec/lbs.

TABLE A - 3

CONFIGURATION EFFECTIVE PARAMETERS

CONFIG.	AVERAGED PR	PR LEVEL	$\dot{P}_{MAX}/F_{AS}$ (1)	$\tau_{R_{Eff}}$ (2)	τ_{Eff} (3)
1-2	5	2	12	0.80	50
1-3	3	1	21	0.80	50
T1	7	3	21		130
T2	8	3	21		160
F2	6	2	15	0.90	120
TOF7	5 (HUD)	2	28	0.78	85
2-2	3	1	19	0.46	50
T1	2	1	19		130
T2	5.5	2	19		160
T3	7	3	19		180
T4	8	3	19		280
F1	3	1	15	0.51	80
F3	6	2	10	0.70	130
T1F1	6	2	15	0.51	160
2-3	3	1	35	0.46	50
T1	4.5	2	35		130
T2	5.5	2	35		160
T3	8.5	3	35		180
F1	3	1	26	0.51	80
F2	3.5	1	23	0.57	100
F3	8	3	18	0.70	130
T1F1	6	2	26	0.51	160
T2F7	4 (HUD)	2	48	0.43	130
2-4	3.5	1	48	0.46	50
T1	5	2	48		130
T2	6	2	48		160
T3	9	3	48		180
F1	2	1	36	0.51	80
F2	2	1	31	0.57	100

TABLE A - 3 (CONT'D)

CONFIGURATION EFFECTIVE PARAMETERS

CONFIG.	AVERAGED PR	PR LEVEL	$\dot{p}_{MAX}/F_{AS}$ (1)	$\tau_{R_{Eff}}$ (2)	τ_{Eff} (3)
F3	7.5	3	25	0.70	130
T1F1	7	3	36	0.51	160
T2F1	9	3	36	0.51	190
3-2	3.5	1	32	0.26	45
3-3	5	2	57	0.26	45
T2	7	3	57		155
T3	7	3	57		175
F1	4.5	2	40	0.33	70
F3	6	2	24	0.51	105
F4	5	2	18	0.70	125
F5	7 (HUD)	3	11	1.16	155
T1F1	7	3	40	0.32	150
3-4	6	2	78	0.26	45
T2	7	3	78		155
F1	2.5	1	55	0.33	70
F3	4	2	34	0.51	105
F4	4	2	25	0.70	125
F5	8	3	16	1.16	155
T1F1	7	3	55	0.32	150
T2F1	8 (HUD)	3	55	0.32	180
5-2	7	3	47	0.16	45
T1	7	3	47		125
T3	8	3	47		175
F1	6	2	30	0.23	65
F2	5	2	24	0.30	75
F3	6	2	17	0.42	90
T0F6	4	2	23	0.40	90
T1F6	6	2	23	0.40	110
T1F1	7 (HUD)	3	31	0.23	140

TABLE A - 3 (CONT'D)

CONFIGURATION EFFECTIVE PARAMETERS

CONFIG.	AVERAGED PR	PR LEVEL	$\dot{p}_{MAX}/F_{AS}$ (1)	$\tau_{R_{Eff}}$ (2)	τ_{Eff} (3)
5-3	7	3	85	0.16	45
T1	7	3	85		125
T2	8	3	85		155
F1	3	1	53	0.23	65
F3	3	1	30	0.42	90
F5	7	3	13	1.08	105
T1F6	7	3	40	0.40	110
T1F1	7	3	53	0.23	140
T2F1	8	3	53	0.23	170
L1-1	4.5	2	6	0.80	50
L1-2	3	1	12	0.80	50
T1	3	1	12		130
T2	6	2	12		160
T3	8	3	12		180
T4	8	3	12		280
F1	4.5	2	10	0.85	90
F2	8	3	8	0.90	120
T1F1	6	2	10	0.85	165
L2-1	2	1	10	0.46	50
T1	4	2	10		130
T2	5	2	10		160
T4	9	3	10		280
F1	3	1	7	0.51	80
F3	3.5	1	5	0.70	130
L2-2	2	1	19	0.46	50
F1	2	1	15	0.51	80
F2	3	1	12	0.57	100
F3	8	3	10	0.70	130

TABLE A - 3 (CONCLUDED)

CONFIGURATION EFFECTIVE PARAMETERS

CONFIG.	AVERAGED PR	PR LEVEL	$\dot{P}_{MAX}/F_{AS}$ (1)	$\tau_{R_{Eff}}$ (2)	τ_{Eff} (3)
L3-1	3.5	1	16	0.26	45
L3-2	2	1	32	0.26	45
T2	5	2	32		155
L4-1	5	2	19	0.21	45
T2	3	1	19		150
F1	3	1	15	0.28	65

NOTES:

(1) $\dot{P}_{MAX}/F_{as}$: Maximum roll acceleration following a unit step F_{AS} input, deg/sec^2/lb.

(2) Effective Roll Mode Time Constant: Calculated from step time history (Section 6), sec.

(3) Effective Time Delay: Calculated from step time history by maximum slope intercept method (Section 6), msec.

APPENDIX B

EVALUATION SEQUENCE

A complete summary of the evaluations in sequence is presented in Table B-1. This table includes all of the evaluations performed during the program. The pilot comment summaries for each evaluation are given in Appendix C; however, several evaluations were invalid and therefore excluded from the pilot rating data used in the discussion of the results (Appendix A). This process was necessary to eliminate those evaluations which were biased by either the experiment task conditions or incorrect simulation mechanization. Evaluations which were rejected are identified in the remarks column of Table B-1 under the following classifications. Additional information is provided in the appropriate pilot comment summaries.

- Aggressive Target:
  The evaluations were invalid because the target aircraft was too aggressive during the unpredictable target tracking task (see Appendix D). The extreme random maneuvers of the target precluded realistic evaluations which consequently led to inaccurate Cooper-Harper pilot ratings based on the experiment guidelines for desired and adequate task performance. Reference, for example, the pilot comments for evaluations 9 and 11. The task performance guidelines are given in Appendix D.
- Gain Setting Error:

  The VSS gains of the NT-33 were incorrectly set to simulate the configuration. Calibration records taken during the evaluation confirmed the erroneous simulation (see Appendix G).

- Configuration In Doubt:

  VSS gains were probably set incorrectly to simulate the configuration since the pilot comments are totally uncharacteristic. Unfortunately, no calibration records are available for verification.

- Anomalous PR:

  Cooper-Harper pilot rating scale was incorrectly used by the evaluation pilot in the context of the evaluation task and the experiment guidelines for task performance.

- Aileron Buzz:

  These evaluations were rejected because aileron buzz (instability of the variable stability system) masked the configuration characteristics and influenced the task/evaluation.

TABLE B-1

EVALUATION SEQUENCE

EVAL. NO.	FLIGHT NO.	PILOT	DATE	TASK	CONF. NO.	RATINGS EP	RATINGS SP	REMARKS
1	2465	B	6 Aug.	Formation	2-2	3	3	1 (Gain Error)
2	↓	↓	↓	and	2-3	5	5	1 (Aggressive Tgt)
3	↓	↓	↓	Gun Tracking	5-2	7	7	
4	2468	B	11 Aug.	ILS	L1-2	2	3	
5	↓	↓	↓	and	L2-1	2	2	
6	↓	↓	↓	Landing	L3-2	2	2	
7	2469	B	12 Aug.	Formation	2-2	6	6	1 (Aggressive Tgt)
8	↓	↓	↓	and	2-2T4	8	8	
9	↓	↓	↓	Gun Tracking	2-3	7	7	1 (Aggressive Tgt)
10	2470	B	13 Aug.	Formation	2-3F1	4	5	1 (Aggressive Tgt)
11	↓	↓	↓	and	2-2	5	3	1 (Aggressive Tgt)
12	↓	↓	↓	Gun Tracking	5-2	7	7	
13	↓	↓	↓		5-2T3	8	8	
14	2471	B	15 Aug.	HUD	2-3F1	5	5	
15	↓	↓	↓	Tracking	2-2T4	9	8	
16	↓	↓	↓	Phase A	2-2	4	4	
17	↓	↓	↓		2-4	2	3	
18	↓	↓	↓		2-4F1	4	4	
19	2472	P	18 Aug.	ILS	L1-1	3	3	
20	↓	↓	↓	and	L1-2T4	8	8	
21	↓	↓	↓	Landing	L4-1	4½	5	

NOTE: 1) Evaluation not used in analysis.

TABLE B-1 (CONT'D)

EVALUATION SEQUENCE

EVAL. NO.	FLIGHT NO.	PILOT	DATE	TASK	CONF. NO.	RATINGS EP	RATINGS SP	REMARKS
22	2473	B	18 Aug.	ILS	L1-2T3	8	8	
23				and	L2-1F1	3	2	
24				Landing	L2-2F3	8	7	
25					L4-1	5	5	
26	2474	B	19 Aug.	ILS	L1-2T1	2	2	
27				and	L2-1T4	9	8	
28				Landing	L2-2	2	2	
29					L4-1N1	4	4	
30	2475	G	20 Aug.	Formation	2-4	3	2	
31				and	2-2T3	7	6	
32				Gun Tracking	3-3F1	5	4½	
33					3-4	7	7	
34	2476	G	20 Aug.	Formation	2-2	5	2	
35				and	2-4T3	9	8	
36				Gun Tracking	5-3	7	7	
37					3-4N1	7	6	
38	2477	P	21 Aug.	Formation	2-2	3	3	
39				and	2-4	5	4	
40				Gun Tracking	2-2T4	8	7	
41	2478	B	21 Aug.	Formation	1-3	3	3	
42				and	3-2	4	3	
43				Gun Tracking	2-3F3	8	8	
44					3-3	5	4	

TABLE B-1 (CONT'D)
EVALUATION SEQUENCE

EVAL. NO.	FLIGHT NO.	PILOT	DATE	TASK	CONF. NO.	RATINGS EP	RATINGS SP	REMARKS
45	2479	B	21 Aug.	Formation	2-2T1	2	2	
46				and	2-4T1	5	5	
47				Gun Tracking	2-2T2	3	3	1 (Configuration in Doubt)
48					3-4T2F1	6	6	1 (Configuration in Doubt)
49					3-4F1	3	3	
50	2481	G	26 Aug.	Air	2-2	3	3	
51				Refueling	3-2	4	4	
52					2-2T3	7	7	
53					2-2T1	2	1	
54					3-4	8	8	
55					3-3F1	4	5	
56	2482	G	27 Aug.	Air	2-3	3	3	
57				Refueling	2-4T2	6	6	
58	2484	B	27 Aug.	Air	2-2	2	3	
59				Refueling	2-3	4	3	
60					2-4F3	8	8	
61					2-4T2	6	5	
62					5-3F1	3	3	
63	2485	B	28 Aug.	Air	2-4F1	2	3	
64				Refueling	2-4F2	2	2	
65					2-3T1	4	4	
66					3-3F3	6	6	
67					5-2T1	7	7	

NOTE: 1) Evaluation not used in analysis.

TABLE B-1 (CONT'D)
EVALUATION SEQUENCE

EVAL. NO.	FLIGHT NO.	PILOT	DATE	TASK	CONF. NO.	RATINGS EP	RATINGS SP	REMARKS
68	2485	B	28 Aug.	Air	5-3F3	2	4	
69	↓	↓	↓	Refueling	3-4N1	5	5	
70	2486	B	28 Aug.	Air	2-3F2	3	3	
71				Refueling	2-4F1	2	2	
72					2-4F2	1	2	
73					3-3T3	7	7	
74					3-4F3	4	4	
75					3-4F1	2	3	
76					5-3F3	3	3	
77	↓	↓	↓	↓	5-2F1	7	6	
78	2487	G	29 Aug.	Air	2-3F1	3	3	
79				Refueling	2-4F2	7	5	1 (Anomalous PR)
80					3-3F4	5	6	
81					3-4F4	4	4	
82	↓	↓	↓	↓	5-3T2F1	8	8	
83	2488	G	29 Aug.	Air	2-3F1	3	3	
84				Refueling	2-3T2	1	3	1 (Anomalous PR)
85					2-3T3	8	8	
86					3-3	7	7	
87					5-3F5	7	6	
88	↓	↓	↓	↓	5-3T2	8	8	
89	2490	P	2 Sept.	HUD Tracking Phase A ILS and Landing	2-3F3	6	6	
90					2-4	3	3	
91	↓	↓	↓		1-2T2	7	5	1 (Incomplete Evaluation)

NOTE: 1) Evaluation not used in analysis.

TABLE B-1 (CONT'D)
EVALUATION SEQUENCE

EVAL. NO.	FLIGHT NO.	PILOT	DATE	TASK	CONF. NO.	RATINGS EP	RATINGS SP	REMARKS
92	2490 (cont)	P	2 Sept.	ILS and	L3-1	4	4	
93	↓	↓	↓	Landing	L3-2T2	5	5	Partial Eval. (VSS Dump)
94	2492	B	4 Sept.	Formation	2-4F3	7	7	
95	↓	↓	↓	and	2-3T2	5	5	
96	↓	↓	↓	Gun Tracking	3-3	3	3	1 (Aileron Buzz)
97	↓	↓	↓	↓	3-4F5	8	8	
98	↓	↓	↓	↓	5-3F6	3	3	1 (Aileron Buzz)
99	2493	P	4 Sept.	Formation	2-3	2	2	
100	↓	↓	↓	and	2-3T2	6	4	
101	↓	↓	↓	Gun Tracking	3-4T2	7	7	
102	2494	B	5 Sept.	Formation	2-2F1	3	3	
103	↓	↓	↓	and	2-4T2F1	9	9	
104	↓	↓	↓	Gun Tracking	3-3	5	5	
105	↓	↓	↓	↓	5-2T0F6	4	3	
106	↓	↓	↓	HUD Tracking Phase A	5-2T1F1	7	7	
107	↓	↓	↓	↓	3-4T2F1	8	8	
108	2495	P	5 Sept.	Formation	2-3T1	6	4	
109	↓	↓	↓	and	2-4T1F1	7	5	
110	↓	↓	↓	Gun Tracking	5-3T1F6	7	5	
111	↓	↓	↓	↓	3-2	3	3	

NOTE: 1) Evaluation not used in analysis.

TABLE B-1 (CONT'D)
EVALUATION SEQUENCE

EVAL. NO.	FLIGHT NO.	PILOT	DATE	TASK	CONF. NO.	RATINGS EP	RATINGS SP	REMARKS
112	2496	B	8 Sept.	Gun	1-3T2	8	9	
113				Tracking	2-3T1F1	6	7	
114					2-2T1F1	5	6	
115					3-3T2	7	7	
116					5-2F1	5	5	
117	2497	P	8 Sept.	Gun	2-3	3	3	
118				Tracking	2-2T1F1	7	6	
119					3-3	4	4	
120					5-3T1F1	7	7	
121					5-3	3	4½	1 (Aileron Buzz)
122	2498	B	9 Sept.	Gun Tracking	1-3F2	6	6	HUD bank tracking task performed prior to pilot rating for Eval. 122 and some following evaluations.
123					2-3T1	3	3	
124					2-4	3	3	
125					3-3T1F1	7	7	
126					5-3T1F6	5	5	1 (Gain Setting error)
127					5-2F2	5	5	
128	2499	P	12 Sept	ILS	L1-2F1	5	3	
129				and	L1-2T2	6	6	
130				Landing	L3-1	3	4	
131					L4-1F1	3	2	

NOTE: 1) Evaluation not used in analysis.

TABLE B-1 (CONT'D)

EVALUATION SEQUENCE

EVAL. NO.	FLIGHT NO.	PILOT	DATE	TASK	CONF. NO.	RATINGS EP	RATINGS SP	REMARKS
132	2500	B	12 Sept	Gun	2-2T2	6	5	
133				Tracking	2-2F3	6	6	
134					2-4N2	4	4	
135				HUD	3-3F3	7	7	
136				Tracking	3-4	4	4	
137				Phase A	3-4N2	3	3	
138	2501	P	12 Sept	Landing	L1-2	4	3	
139					L2-1T2	5	3	
140	2502	P	15 Sept	Landing	L1-2F2	8	8	
141					L1-2	3	3	
142					L2-1F3	4	5	
143					L2-2F1	2	3	
144					L2-2D1	2	2	
145					L4-1N4	4½	2	
146	2503	B	16 Sept	Gun	1-3T1	7	5	
147				Tracking	2-4T2N2	5	5	
148					2-3F2	4	3	
149					3-3F4	5½	6	
150	2504	P	16 Sept	Landing	L1-2T1F1	6	3	
151					L1-2F1	4	3	
152					L2-1T1	4	3	
153					L2-2	2	3	

TABLE B-1 (CONT'D)
EVALUATION SEQUENCE

EVAL. NO.	FLIGHT NO.	PILOT	DATE	TASK	CONF. NO.	RATINGS EP	RATINGS SP	REMARKS
154	2504	P	16 Sept	Landing	L3-1N2	4	2	
155	(cont)	↓	↓	↓	L3-1D1	2	2	Rudder Command Gains increased from this evaluation on [for LA]
156	↓	↓	↓	↓	L4-1T2	3	3	
157	2505	B	18 Sept	Gun	2-2	3	2	
158	↓	↓	↓	Tracking	2-3T3	9	8	
159	↓	↓	↓	↓	2-4T1F1N2	8	8	
160	↓	↓	↓	↓	2-4T2N2	5	5	
161	↓	↓	↓	↓	3-4N2	4½	4	
162	↓	↓	↓	↓	3-3D2	2	2	
163	↓	↓	↓	↓	5-3D2	5	5	1 (Gain Setting Error)
164	↓	↓	↓	↓	5-3F1D2	3	3	
165	2506	B	18 Sept	Gun	1-2	5	5	
166	↓	↓	↓	Tracking	2-4F2	7	6	1 (Configuration in Doubt)
167	↓	↓	↓	↓	5-2T1F6	6	6	
168	↓	↓	↓	↓	5-3N2	4½	4	
169	↓	↓	↓	↓	3-4T1F1N2	8	8	
170	↓	↓	↓	↓	3-4T1F1	7	7	
171	2507	P	18 Sept	HUD	1-3T0F7	5	5	
172	↓	↓	↓	Tracking	2-3T2F7	4	4	
173	↓	↓	↓	Phase A	2-4F3	7	6	

NOTE: 1). Evaluation not used in analysis.

TABLE B-1 (CON'T)

EVALUATION SEQUENCE

EVAL. NO.	FLIGHT NO.	PILOT	DATE	TASK	CONF. NO.	RATINGS EP	RATINGS SP	REMARKS
174	2507 (cont)	P	18 Sept	HUD Tracking	5-3N3	4	4	
175	↓	↓	↓	Phase A	5-3T1N3	2	3	
176	↓	↓	↓	Landing	L3-1D1	4	3	
177	2508	B	19 Sept	Gun	2-2T2	5	6	
178	↓	↓	↓	Tracking	2-3T1	4	4	
179	↓	↓	↓	↓	2-4F2	3	3	
180	↓	↓	↓	↓	2-3	2	1	
181	↓	↓	↓	↓	2-3D2	3	2	
182	↓	↓	↓	↓	3-3D2	2	2	
183	↓	↓	↓	↓	3-3T2D2	6	6	
184	↓	↓	↓	HUD Tracking Phase A	5-3	7	5	
185	2509	B	19 Sept	Gun Tracking	4-2	5	5	(Configuration in doubt)
186	↓	↓	↓	↓	2-4F1N2	5	5	
187	↓	↓	↓	↓	5-2F3	6	6	
188	↓	↓	↓	↓	5-3F3	4	4	
189	↓	↓	↓	↓	5-3T1	7	7	
190	↓	↓	↓	↓	5-3	4(7)	4	PR = 7 used, see pilot comments.
191	↓	↓	↓	↓	3-4	4	4	
192	2510	P	20 Sept	Landing	L1-1	6	6	10° Crab on final
193	↓	↓	↓	↓	L1-2T1	4	4	One Touchdown/Eval

NOTE: 1) Evaluation not used in analysis.

TABLE B-1 (CONCLUDED)
EVALUATION SEQUENCE

EVAL. NO.	FLIGHT NO.	PILOT	DATE	TASK	CONF. NO.	RATINGS EP	RATINGS SP	REMARKS
194	2510 (cont)	P	20 Sept	Landing	L2-1F3	3	3	One Touchdown/Eval
195					L2-2F2	3	3	
196					L2-2D1	2	2	
197					L4-1N2	2	2	
198	2511	P	20 Sept	HUD	2-3T2	4½	5	
199				Tracking	2-4F2	3	3	
200				Phase A	3-3	2	3	
201					3-3F5	7	7	
202					5-3T1N3	4½	6	
203					3-3T1D2	3	2	
204					3-4T1F4 D2	8	7	
205					3-3T1D2	2	2	
206				Landing	L4-1T2	3	3	
207	2512	B	20 Sept	HUD	1-2	7	7	
208				Tracking	2-4T2	7	6	
209				Phase A	5-2	6	5	1 (Gain Setting Error)
210					5-3	4(7)	4	PR = 7 used, see pilot comments.
211					3-4F1N2	5	5	
212					3-4	5	5	
213					3-4F4	8	7	
214				Landing	L3-2	5	5	1 (Configuration in Doubt)

NOTE: 1) Evaluation not used in analysis.

APPENDIX C

PILOT COMMENT DATA

The pilot comment summaries for all the evaluations performed during this experiment are presented in this appendix. The title block for each evaluation contains the pertinent information to allow quick cross reference to the tables found in Appendices A and B. Where appropriate, special remarks are included to explain the reasons for deleting an evaluation from the experiment data base or provide added information. The summaries presented were prepared from the complete tape recorded pilot comments.

EVALUATION NO. 165	CONFIGURATION NO. 1-2	PILOT: B	TASK: Gun tracking
τ_R = .8	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

No PIO or ratcheting - just sluggish. Initial response bad - even final response felt bad for a given input. Predictability not bad for small motions "predictably sluggish." Predictability poor for large motions. Aggressiveness helped - had to be aggressive to get pipper to go anywhere near where I wanted it. Fine tracking pretty good - pipper stayed where I put it. Gross acquisition bad. Rudder helped some - not as much as I expected.

CONTROL SYSTEM FEEL:

Lateral forces high - both initial and steady state. Displacements felt high - maybe because I was overdriving it. Sensitivity very low - sluggish. Harmony beginning to be bad.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 207	CONFIGURATION NO. 1-2	PILOT: B	TASK: HUD tracking Flight Phase Cat.A
τ_R = .8	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

No PIO - but got one overshoot because it was so sluggish. Initial response very slow getting started. Final response took a lot of force/large input to get desired roll rate. Predictability poor - took so long to get going. More aggressive I was the bigger the overshoot was - worse accuracy.

CONTROL SYSTEM FEEL:

Lateral force high and displacement large to get response I wanted. Sensitivity terrible. Harmony bad - much heavier laterally than in pitch.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 41	CONFIGURATION NO. 1-3	PILOT: B	TASK: Formation and gun tracking

τ_R = .8	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No undesirable motions Initial and final response both fine. Very predictable. Could be aggressive and abrupt as well as smooth. Fine tracking good. Gross acquisition also good but there were one or two overshoots - partly due to pilot technique. Did use some rudder - just to speed the motion on. Random tracking - didn't use any compensation techniques for other tasks at all.

CONTROL SYSTEM FEEL:

Forces/displacements/harmony/sensitivity fine.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Formation and predictable tracking is PR=2. Random tracking is PR=3.

HUD TRACKING:

No problem at all with bank tracking or heading tracking, similar to other tasks.

EVALUATION NO. 146	CONFIGURATION NO. 1-3T1	PILOT: B	TASK: Gun tracking
τ_R = .8	p/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

PIO - low amplitude - not sharp - not ratcheting. Happens during small inputs - fairly fast oscillations - several overshoots. Initial response slow/sluggish. Predictability degraded. Couldn't stop oscillations if I was aggressive or not. Fine tracking was more problem than gross acquisition. Rudder didn't help.

CONTROL SYSTEM FEEL:

Lateral forces not bad - felt light during PIO. Felt heavier for larger inputs. Displacements OK for large corrections - seemed higher for small inputs. Sensitivity low for small inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Not done.

EVALUATION NO. 112	CONFIGURATION NO. 1-3T2	PILOT: B	TASK: Gun tracking

τ_R = .8	P/F_{AS} = 18	TIME DELAY: .105	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 9	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Definite PIO. Overshot everytime. Not ratcheting. Very loose. Slower PIO. Not divergent but took a lot of cycles to damp out. Final response/ roll rate good. Initial response - slow getting started - maybe because of overshoots. Predictability was terrible. More aggressive I was the worse it got. Gross acquisition not as bad as fine tracking. Rudder helped a bit.

CONTROL SYSTEM FEEL:

Reasonable forces and displacements. Low sensitivity initially.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

See same PIO/overshoots. Feels the same.

EVALUATION NO. 122	CONFIGURATION NO. 1-3F2	PILOT: B	TASK: Gun tracking

τ_R = .8	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.17s+1}$	REMARKS: Bank tracking prior to PR from this evaluation on.	SAFETY PILOT RATING 6	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

Overshoots - a couple, not really a big PIO, certainly not ratcheting. Slow getting started. Initial response slow. Can feel roll rate build up - then it really takes off. Final response - could get a good roll rate if you waited. Predictability terrible. Precision accuracy poor. Worse with aggressiveness. Gross acquisition harder than fine tracking. Rudder definitely helped.

CONTROL SYSTEM FEEL:

Lateral forces high/displacements high/sensitivity low initially - maybe because I was overdriving it to start. Harmony - very definitely heavier in pitch than in roll.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING: None.

OTHER: A poor 6.

HUD TRACKING: Spongy, overshoots.

EVALUATION NO. 171	CONFIGURATION NO. 1-3T0F7	PILOT: P	TASK: HUD tracking Flight Phase Cat.A

τ_R = .8	p/F_{AS} = 18	TIME DELAY: .055	COMMAND GAIN: Linear

PRE-FILTER: $\frac{.05s+1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

One overshoot for large amplitude inputs. Initial response good. Final response not very predictable. Got more roll rate than I expected - overbanked. Not so much a function of aggressiveness as of size of correction required. Didn't use compensation. Could track fairly precisely with small inputs.

CONTROL SYSTEM FEEL: OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING: None.

HUD TRACKING: Not done.

OTHER:

EVALUATION NO. 1	CONFIGURATION NO. 2-2	PILOT: B	TASK: Formation and Gun Tracking
$\tau_R = 0.45$	$p/F_{AS} = 10$	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Incorrect VSS gain setting used - not used in analysis	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL :

No PIO. Initial and final response O.K.. Aggressiveness helped accuracy. No unusual compensation techniques required.

LATERAL POSITION CONTROL :

Good accuracy.

CONTROL SYSTEM FEEL :

Forces fine. Displacement fine. Harmony fine.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING :

Negligible.

OTHER :

Nice flying airplane.

EVALUATION NO. 7	CONFIGURATION NO. 2-2	PILOT: B	TASK: Formation and gun tracking
$\tau_R = .45$	$p/F_{AS} = 10$	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Target too aggressive. Not used in analysis.	SAFETY PILOT RATING 6	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

No undesirable motions. Slow to get started - final response OK. Not too predictable during fine tracking. Got worse when I was aggressive. Fine tracking worse than gross acquisition. Rudders were a big help in moving pipper.

CONTROL SYSTEM FEEL:

No complaints, except maybe a bit heavy forces to get started.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

PR=6 is for tracking. Formation definitely better, maybe PR=3 for formation.

EVALUATION NO. 34	CONFIGURATION NO. 2-2	PILOT: G	TASK: Formation and gun tracking
τ_R =.45	P/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 5*

ROLL ATTITUDE CONTROL:

No undesirable motions. Very predictable. Accurate. No tendency to over-control as aggressiveness is increased during fine tracking. Fine tracking - not as much roll rate as you expect there to be. Some tendency to over-control bank during gross acquisition because you use larger inputs.

CONTROL SYSTEM FEEL:

Lateral stick was heavy.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

* EP gave 3 separate ratings. PR=2 for formation, 2 for fine tracking and 5 for gross acquisition.

HUD TRACKING:

Tended to overshoot small bank angles - give PR= 4/5 for HUD bank tracking.

EVALUATION NO. 11	CONFIGURATION NO. 2-2	PILOT: B	TASK: Formation and gun tracking
τ_R =.45	P/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Target too aggressive. Not used in analysis.	SAFETY PILOT RATING 3	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

No undesirable motions at all. Predictable. Initial and final response pleasant. Fine tracking really nice once I got on target. Gross acquisition not quite as good but adequate. Very little compensation required.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Very easy to fly in formation (PR=2). PR=5 due to inability to achieve desired performance during unpredictable gun tracking.

EVALUATION NO. 38	CONFIGURATION NO. 2-2	PILOT: P	TASK: Formation and gun tracking
τ_R =.45	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No real undesirable motions. Initial response and final response predictable. Aggressiveness didn't create problems. Could do gross acquisition and fine tracking OK. Used some rudder during fine tracking.

LATERAL POSITION CONTROL:

Had more trouble with pitch than roll - pilot proficiency/technique? was very comfortable with lateral control.

CONTROL SYSTEM FEEL:

Forces comfortable, although I might prefer a bit heavier pitch force. Displacements/sensitivity OK. Harmony - maybe pitch a bit light.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 157	CONFIGURATION NO. 2-2	PILOT: B	TASK: Gun tracking
τ_R =.45	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

One small overshoot when I was aggressive. Felt like a heavy airplane - but was easy to get desired performance. Initial response - just a little sluggish - minor problem. Final response/roll rate available - took a lot of force. Was predictable. Didn't see overshoot if I was less aggressive. Rudder did help a bit getting started.

CONTROL SYSTEM FEEL:

Lateral forces a bit heavy. Sensitivity a shade low but well within reason.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Almost no turbulence - does not affect rating.

EVALUATION NO. 50	CONFIGURATION NO. 2-2	PILOT: G	TASK: Aerial refueling

τ_R=0.45	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Adequate for mission in lateral control; nothing wrong with it. No undesirable motions. Initial/final response in good coordination. Predictability - very predictable. Precision was there. Had to use rudder in turbulence once in a while (turbulence from tanker wake). No overshoots that I could detect. No compensation techniques. Very controllable.

CONTROL SYSTEM FEEL:

Control harmony was good. Sensitivity good. Displacements were small but good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Little bit of very high frequency turbulence behind tanker; very little effect except to cause sideslip on machine.

HUD TRACKING:

Not done.

EVALUATION NO. 58	CONFIGURATION NO. 2-2	PILOT: B	TASK: Air refueling

τ_R = .45	P/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 2

LATERAL POSITION CONTROL:

No overshoots. Could be aggressive without hurting accuracy or precision. Compensation techniques - maybe used rudder a bit.

CONTROL SYSTEM FEEL:

Fine.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Some turbulence and directional disturbances when behind tanker - only minor effect on rating.

HUD TRACKING:

Not done.

EVALUATION NO. 16	CONFIGURATION NO. 2-2	PILOT: B	TASK: HUD tracking Flight Phase Cat. A

τ_R = .45	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL :

No undesirable motions. Slow getting started — but final roll rate was available if you pushed hard enough. Predictability O.K.. Had to be aggressive to do task. Aggressiveness helped accuracy. Took more effort to move airplane where you wanted it. No big difference fine vs. gross maneuvers. Didn't use rudder. Only compensation technique was overdriving with stick.

CONTROL SYSTEM FEEL :

Felt heavy in roll — like a big airplane. Displacement O.K.. Sensitivity way too low. Prefer more sensitivity. Lacked a bit in harmony because of heavy aileron force.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING :

None.

EVALUATION NO. 45	CONFIGURATION NO. 2-2T1	PILOT: B	TASK: Formation and gun tracking
τ_R=.45	P/F_{AS} = 10	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

Initial and final response fine. No undesirable motions. Very predictable. Could be aggressive with no problem. Fine tracking and gross acquisition both good. No compensation techniques required, although during gross maneuvering I occasionally tended to use rudder - it did help but I really didn't need it.

CONTROL SYSTEM FEEL:

Forces/displacements/sensitivity/harmony all good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

No problem with formation or tracking. Could be a PR=1.

EVALUATION NO. 53	CONFIGURATION NO. 2-2T1	PILOT: G	TASK: Aerial refueling
$\tau_{R=0.45}$	$P/F_{AS} = 10$	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 1	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

Very nice - HQR=2. No undesirable motions. Initial vs. final response - very linear - felt as if I had total control over aircraft. Very predictable. Precision and accuracy did not degrade with aggressiveness. Very easy to track. Only compensation was a little rudder because of tanker wake. If I had an overshoot it was because I misjudged it (a half a cycle). Very easy to get behind the drogue and stay there. Either small or large changes could be done with confidence.

CONTROL SYSTEM FEEL:

Displacements - reasonable. Sensitivity was linear and right. Harmony was there.

OTHER:

Very easy to get aggressive, approach the drogue at a high closure rate and still feel comfortable with it.

HUD TRACKING:

Not done.

EVALUATION NO. 132	CONFIGURATION NO. 2-2T2	PILOT: B	TASK: Gun tracking

τ_R = .45	p/F_{AS} = 10	TIME DELAY: .105	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

No ratcheting or PIO - one overshoot for gross acquisition. Not terrible. Initial response - slow and sluggish. Final response/roll rate OK if you accepted the heavy forces. Predictability not very good - you put input in - see response build up OK, but you couldn't tell when it was going to stop. Hard to be as aggressive as I wanted to be, but increased aggressiveness made it worse. Fine tracking not too bad - had some trouble controlling pipper. Rudder did help. Compensation - tended to overdrive it to get response.

CONTROL SYSTEM FEEL:

Lateral forces too high. Lateral displacement seemed high because of over-driving. Sensitivity extremely low. Harmony beginning to be a problem - heavy laterally.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING: None.

HUD TRACKING:

Sluggish - heavy - one overshoot, during bank tracking.

EVALUATION NO. 177	CONFIGURATION NO. 2-2T2	PILOT: B	TASK: Gun tracking

τ_R = .45	p/F_{AS} = 10	TIME DELAY: .105	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Sloppy feeling - one overshoot - not a PIO. Initial response was the problem - loose. Final response/roll rate OK. Predictability hurt by looseness - put input in - response didn't start right away. More aggressive I was the more I overshot. Problem was in fine tracking. Took several inputs/ longer time to get pipper right on the fuselage. Gross acquisition not bad. Compensation - had to make an extra input to start or stop.

CONTROL SYSTEM FEEL:

Forces OK. Sensitivity a bit low starting.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 47	CONFIGURATION NO. 2-2T2	PILOT: B	TASK: Formation and gun tracking
τ_R = .45	P/F_{AS} = 10	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Conf. in doubt. Not used in analysis.	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Had some trouble with random tracking. No undesirable motions. Initial and final response fine. Was predictable. Didn't notice any large degradation in performance as I got more aggressive. Fine and gross tracking pretty good - gross acquisition a bit more difficult than fine tracking. Rudder did help - to get pipper moving in right direction right away.

CONTROL SYSTEM FEEL:

Lateral forces a little heavy but well within usable range. Sensitivity/ harmony/displacements OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Might give PR=2 for formation.

HUD TRACKING:

On bank tracking - see that initial response is a little bit sluggish - doesn't bother performance that much - can get what I want - but makes for a bit heavier force starting out. Won't change rating.

EVALUATION NO. 31	CONFIGURATION NO. 2-2T3	PILOT: G	TASK: Formation and gun tracking
$\tau_{R=.45}$	$p/F_{AS} = 10$	TIME DELAY: .125	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Nonlinear around neutral - have to get the stick out away from neutral to get reasonable response. Undesirable motions present - induced by the pilot trying to keep a sense of airplane response. Initial response for small stick inputs was not there - for large inputs it was there and matched final response. Predictability the same. Couldn't be aggressive - had to accept a motion then try to change it. Compensation technique - I rapped the stick through the sort of dead zone in the middle.

CONTROL SYSTEM FEEL:

Displacements/sensitivity/harmony OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Gross acquisition not too bad.

HUD TRACKING:

Tend to overshoot bank angle for heading task.

EVALUATION NO. 52	CONFIGURATION NO. 2-2T3	PILOT: G	TASK: Aerial refueling
τ_R=0.45	p/F_{AS} = 10	TIME DELAY: .125	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Controllable/PR=7. If any natural turbulence, I don't think we could have gotten close to the drogue; as it was I was leary about getting close to the drogue with any closure rate at all, just enough to lock the probe. I did it only because I was well stabilized behind the drogue before doing it. Didn't feel close control over attitude at all. Not really any ratcheting although the initial response - there didn't seem to be any. Once it got going it was OK. Put the control in and it wouldn't seem to respond at all. Unpredictable. Aggressiveness would not help like it did for the second one (#51). Overshoots - typically two. Precision just not there - small changes were more difficult than large.

CONTROL SYSTEM FEEL:

Harmony not there.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Did not affect this evaluation - if it were present it would have really affected it.

HUD TRACKING:

Not done.

EVALUATION NO. 8	CONFIGURATION NO. 2-2T4	PILOT: B	TASK: Formation and gun tracking
τ_R = .45	p/F_{AS} = 10	TIME DELAY: .225	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Definite roll oscillation - random - not constant frequency. Wasn't PIO or ratcheting. Both initial and final response poor. Also poor predictability. Precision poor. Harder I worked, the worse it got. Gross acquisition bad, but fine tracking worse. Rudder didn't help.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON RATING:

None.

OTHER:

Formation just about as bad (PR=8) as gun tracking.

HUD TRACKING:

Several bank overshoots during bank tracking. The harder I work at it, the more they keep on going.

EVALUATION NO. 15	CONFIGURATION NO. 2-2T4	PILOT: B	TASK: HUD tracking Flight Phase Cat. A
τ_R = .45	p/F_{AS} = 10	TIME DELAY: .225	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 9

ROLL ATTITUDE CONTROL:

Large overshoots. Initial response practically nil. Had to put in an awful force to get started. Final response all over the place. Predictability horrible. It was so bad I had to back off so I was flying very smoothly to see improvement. Any amount of aggressiveness for large corrections would cause it to go off. Could never do fine tracking because of overshoots. Had to almost fly open loop. Sluggish, only compensation was to back way off on task — could not tighten up at all. Rudders didn't help.

CONTROL SYSTEM FEEL :

Ailerons feel really heavy — much heavier than pitch. Harmony a problem. Insensitive. Displacements O.K..

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING :

None.

EVALUATION NO. 40	CONFIGURATION NO. 2-2T4	PILOT: P	TASK: Formation and gun tracking
$\tau_R = .45$	$p/F_{AS} = 10$	TIME DELAY: .225	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Tend to PIO a little bit, overcontrol - due to very perceptible initial lag. Initial response unpredictable - once you got things going it was OK. Seemed to bother gross acquisition more than smaller corrections. Tendency to overcontrol anytime my gain was up. Aggressiveness increased problems. Had difficulty in gross acquisition - in terms of getting going - and then getting more than I wanted. No compensation technique was used.

LATERAL POSITION CONTROL:

Noticed pitch control degraded because of my concentration with roll problems.

CONTROL SYSTEM FEEL:

Forces high initially, but OK in steady maneuver. Displacements OK. Initial sensitivity low in relation to final sensitivity.

TURBULENCE/CROSSWIND EFFFCT ON PILOT RATING:

None.

HUD TRACKING:

Bank tracking brings out problem more than heading tracking - produces oscillations. Would give same PR (8).

EVALUATION NO. 102	CONFIGURATION NO. 2-2F1	PILOT: B	TASK: Formation and gun tracking
τ_R =0.45	P/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Rudder speeded up response especially when being aggressive (minimal compensation). No undesirable motions. A little slow getting started, final response fine. Predictability - no problem. Aggressiveness didn't play a part. Fine tracking was beautiful/gross acquisition a little slow; well within reason. Compensation - rudder used a little.

CONTROL SYSTEM FEEL:

Roll heavier than others, still OK. Displacement OK. Sensitivity a little low, OK however.

EVALUATION NO. 133	CONFIGURATION NO. 2-2F3	PILOT: B	TASK: Gun tracking
τ_R = .45	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

No ratcheting - sluggish. Got maybe two overshoots when I tried to stop roll rate. Initial response sluggish. Final response - roll rate took a high force - but was available if I wanted to wait for it. Predictability very poor. Aggressiveness degraded precision and accuracy. One bank overshoot during gross acquisition. Had trouble controlling pipper during fine tracking - kept putting in inputs. Rudder helped. Compensation - overdriving and reduced aggressiveness.

CONTROL SYSTEM FEEL:

Lateral forces high. Lateral displacements high due to overdriving. Sensitivity very, very low. Harmony problem - affected pitch control.

OTHER:

A poor PR=6.

HUD TRACKING:

Would have given PR=7 for bank tracking alone- 2 or 3 overshoots.

EVALUATION NO. 118	CONFIGURATION NO. 2-2T1F1	PILOT: P	TASK: Gun tracking
τ_R =0.45	p/F_{AS} = 10	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Aircraft was heavy initially - lagged. Initial response was sluggish. Tended to overshoot. Final response still felt sluggish. Predictability was a problem - even for small inputs. Aggressiveness hurt aircraft precision. Rudder not used but might have helped.

CONTROL SYSTEM FEEL:

Forces too high - hands/arms got tired during tracking. Displacements OK. Not good sensitivity - lagged initially, then jumped out at you, but even then you didn't get as much as you really wanted. Harmony - out of wack.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 114	CONFIGURATION NO. 2-2T1F1	PILOT: B	TASK: Gun tracking
τ_R =.45	p/F_{AS} = 10	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

No PIO or ratcheting or particular overshoots. Initial response sluggish. Getting the nose to point towards him was the tough part - once I got it on him I could hold it there fairly well. Fine tracking not bad. If I waited long enough I could get a response. Poor predictability. Aggressiveness didn't make much difference. Gross acquisition was the problem.

CONTROL SYSTEM FEEL:

Wouldn't want lateral force any higher - initial sensitivity was too low. Maybe overdriving lateral displacement to get started.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING (Bank):

Saw one overshoot and previously described sluggishness.

EVALUATION NO. 2	CONFIGURATION NO. 2-3	PILOT: B	TASK: Formation and Gun Tracking
τ_R =.45	p/F_{AS} =18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Target too aggressive; not used in analysis	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Slight wing rocking in close formation – didn't build up. Initial/final performance fine. Final roll rate fine. Predictability a problem during large maneuvers. Being aggressive hurt precision. Didn't find any compensation technique that worked well.

LATERAL POSITION CONTROL:

Didn't overshoot. Seemed precise. Could hold position during formation.

CONTROL SYSTEM FEEL :

Felt sloppy. Forces/displacements fine.

TURBULENCE/CROSSWIND EFFECT ON RATING:

No turbulence.

EVALUATION NO. 9	CONFIGURATION NO. 2-3	PILOT: B	TASK: Formation and gun tracking
τ_R =.45	p/F_{AS} =18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Target too aggressive, not used in analysis	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Quick, short oscillations. Choppy, especially for initial motion. Final response OK. Could get to general area of target easily, fine tracking was a problem. Rudder didn't help. Flying smoothly did help some.

CONTROL SYSTEM FEEL:

Sensitive – somewhat jerky.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Rating due to inability to achieve adequate performance during unpredictable gun tracking.

EVALUATION NO. 99	CONFIGURATION NO. 2-3	PILOT: P	TASK: Formation and gun tracking
τ_R =.45	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

Good attitude control. Comfortable. Initial and final response fine. Predictable. Could be aggressive and still be precise. Gross acquisition plus fine tracking good.

LATERAL POSITION CONTROL:

Good - no overshoots.

CONTROL SYSTEM FEEL:

Comfortable.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING (Bank):

If aggressive - see one overshoot. Didn't see this previously - would give PR=3 for bank tracking.

EVALUATION NO. 117	CONFIGURATION NO. 2-3	PILOT: P	TASK: Gun tracking
τ_R =0.45	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Attitude control good. No undesirable motions. No tendency to ratchet. Very good initial and final response - predictable. Might have a small overshoot if really aggressive but not a worry. No difference between tasks. Rudder makes no difference.

CONTROL SYSTEM FEEL:

Forces/displacements - comfortable. Sensitivity - no problem. Harmony -good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 180	CONFIGURATION NO. 2-3	PILOT: B	TASK: Gun tracking
τ_R = .45	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 1	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No PIO or ratcheting. Initial/final response fine. Predictability good. Responsive but not sharp.

CONTROL SYSTEM FEEL:

Fine.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 56	CONFIGURATION NO. 2-3	PILOT: G	TASK: Air refueling
τ_R =0.45	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Precise (but maybe see one little wing waggle a couple of times). No undesirable motions. Initial and final response very predictable. Could be aggressive and maintain precision. Compensation - fuselage wash from A-3 tanker caused T-33 to sharply yaw - so I used a steady heading sideslip to prevent it.

CONTROL SYSTEM FEEL:

Forces/sensitivity/displacements/harmony good.

HUD TRACKING:

Not done.

EVALUATION NO. 59	CONFIGURATION NO. 2-3	PILOT: B	TASK: Air refueling

τ_R = .45	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Slight ratcheting - annoying - didn't really hurt position control. One overshoot if I was aggressive.

LATERAL POSITION CONTROL:

One overshoot in fine control. Could do aggressive offset capture OK. Compensation - had to hold stick lightly - minimized overshoots. Used rudder because of tanker airflow effects.

CONTROL SYSTEM FEEL:

Lateral sensitivity a bit high initially for small inputs. OK for larger steady inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker caused buffet, directional changes.

HUD TRACKING:

Not done.

EVALUATION NO. 108	CONFIGURATION NO. 2-3T1	PILOT: P	TASK: Formation and gun tracking
τ_R =0.45	P/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

One or two overshoots and had a tendency to overcontrol even in formation. Some unpredictability. Initial response felt spongy, then got more response than expected. Problem was I felt uncomfortable with initial response. Fine track and gross acquisition were both affected. No rudder used. Precision a function of aggressiveness (grew worse if more aggressive).

LATERAL POSITION CONTROL:

Some tendency to overshoot, although it wasn't bad. Definitely uncomfortable about moving in too close.

CONTROL SYSTEM FEEL:

Forces - OK. Sensitivity - felt it was a "response shape" problem rather than sensitivity. Harmony wasn't a problem.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING: None.

HUD TRACKING:

Looks like random track maneuver - PR=6.

EVALUATION NO. 123	CONFIGURATION NO. 2-3T1	PILOT: B	TASK: Gun tracking
τ_R =.45	P/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial response was quick - but not much of a problem once I learned about it. Final response fine. Predictability fine. Precision/accuracy fine and not affected by aggressiveness. Gross acquisition no problem once I learned how to handle sensitivity. Higher initial sensitivity is reason for PR=3. Fine tracking good. No compensation required.

CONTROL SYSTEM FEEL:

Forces/displacements fine. Sensitive/responsive but not unreasonably so.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 65	CONFIGURATION NO. 2-3T1	PILOT: B	TASK: Air refueling
$\tau_R = .45$	$P/F_{AS} = 18$	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

One overshoot - definitely working harder. No PIO.

LATERAL POSITION CONTROL:

Didn't have really fine control - probe moving within diameter of basket. Could be aggressive without obviously increasing problems. Compensation technique - just had to work harder.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 178	CONFIGURATION NO. 2-3T1	PILOT: B	TASK: Gun tracking
$\tau_R = .45$	$P/F_{AS} = 18$	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

No PIO, no ratcheting. Small overshoot if I was aggressive - annoying. Initial response - little bit of looseness/sloppiness for small quick corrections. Final response was very nice. Predictability still good. Aggressiveness did cause some degradation in accuracy - but not too much. Gross acquisition no problem. Fine tracking was a problem - not bad - just not tight enough.

CONTROL SYSTEM FEEL:

Lateral sensitivity a little low initially.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

A good PR=4.

EVALUATION NO. 95	CONFIGURATION NO. 2-3T2	PILOT: B	TASK: Formation and gun tracking
$\tau_R = .45$	$p/F_{AS} = 18$	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Maybe one overshoot with large input - not too bad. Initial response - took off a bit - very responsive - more than I would like. Final response/ roll rate OK - it was just the initial jump in roll rate I didn't like - that hurt predictability - especially for fast/aggressive inputs. Lots of aggressive inputs gave feeling of rolling in steps, instead of nice smooth response. Gross acquisition OK. Fine tracking a little tough. A little rudder helped in fine tracking. Other compensation - take my time moving pipper.

CONTROL SYSTEM FEEL:

Forces/displacements fine. Lateral sensitivity a little high on initial roll response.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Formation considerably easier - PR=4.

HUD TRACKING:

See same overshoot and rapid build up of roll rate - would give PR=6.

EVALUATION NO. 100	CONFIGURATION NO. 2-3T2	PILOT: P	TASK: Formation and gun tracking

τ_R = .45	p/F_{AS} = 18	TIME DELAY: .105	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

Small overshoots in roll for small corrections. Somewhat unpredictable final response - got more roll rate than I anticipated initially. Looked like lag in initial response. Definitely function of aggressive and amplitude. Precision better for small/less aggressive inputs. Fine tracking easier than gross acquisition. Rudder did help.

LATERAL POSITION CONTROL:

Could hold formation position OK - but aircraft control was a bit uncomfortable

CONTROL SYSTEM FEEL:

Some disparity between pitch and roll for large roll inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING: None.

HUD TRACKING:

Airplane wanted to jump initially - saw same initial roll disparity as previously.

EVALUATION NO. 84	CONFIGURATION NO. 2-3T2	PILOT: G	TASK: Air refueling
τ_R = .45	P/F_{AS} = 18	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Anomalous rating. Not used in the analysis	SAFETY PILOT RATING 3	EVAL PILOT RATING 1

ROLL ATTITUDE CONTROL:

Very precise, even if aggressive. Very predictable even for big inputs. No overshoots. No compensation required.

LATERAL POSITION CONTROL:

Could put probe where I wanted it.

CONTROL SYSTEM FEEL:

Good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects. Also some light atmospheric turbulence.

HUD TRACKING:

Not done.

EVALUATION NO. 198	CONFIGURATION NO. 2-3T2	PILOT: P	TASK: HUD tracking Flight Phase Cat.A
τ_R = .45	P/F_{AS} = 18	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 4½

ROLL ATTITUDE CONTROL:

Jumpy starting and stopping roll. Small overshoot tendency if aggressive. Initial response quick - maybe too quick. Final response - tend to overshoot if aggressive. Precision degraded some by aggressiveness/ large inputs.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 85	CONFIGURATION NO. 2-3T3	PILOT: G	TASK: Air refueling

τ_R = .45	p/F_{AS} = 18	TIME DELAY: .125	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Attitude control difficult due to pilot overcontrol. Undesirable motions - diverging PIO/many overshoots. Too sensitive around neutral. Attitude unpredictable - hard to stop. Precision poor with low aggressiveness - approaches uncontrollability with increasing aggressiveness. Compensation technique - quickly changed frequency of stick inputs when 2nd PIO started. Unwilling to make large inputs.

CONTROL SYSTEM FEEL:

Forces light. Sensitivity very high. Displacements small.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 158	CONFIGURATION NO. 2-3T3	PILOT: B	TASK: Gun tracking

τ_R = .45	p/F_{AS} = 18	TIME DELAY: .125	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 9

ROLL ATTITUDE CONTROL:

PIO - several oscillations - in certain circumstances could go divergent. Smooth - not ratcheting. Initial response - maybe a little pause. Final response - took off like crazy - predictability really terrible. Problem there even when I was non-aggressive - got worse when I was aggressive. Gross acquisition - not acceptable but could get pipper near target. Fine tracking was terrible - small corrections quickly built into PIO's. Rudder didn't help. Nothing helped except backing off on task.

CONTROL SYSTEM FEEL:

Forces OK. Sensitivity maybe a little low initially - then response really took off - high final sensitivity.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

No effect.

EVALUATION NO. 78	CONFIGURATION NO. 2-3F1	PILOT: G	TASK: Air refueling
τ_R=.45	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No undesirable motions. Precise attitude control. Predictable, but not really 100%. Initial/final response good. Could be aggressive and still be precise. No compensation required. Felt a little bit of difference in pitch and roll axes - not quite coordinated.

LATERAL POSITION CONTROL:

Could move aircraft where I wanted to.

CONTROL SYSTEM FEEL:

Lateral sensitivity a bit low.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 83	CONFIGURATION NO. 2-3F1	PILOT: G	TASK: Air refueling

τ_R = .45	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Initial/final response good for small stick inputs. Predictability fine for small inputs. A little tough to make bank angle stop just where you want it for larger inputs. Didn't see any big degradation in accuracy when I was aggressive - maybe did lead correction a bit a couple of times. No major overshoots. Couple of minor overshoots during aggressive offset maneuvers. No real compensation required.

LATERAL POSITION CONTROL:

Very accurate for small inputs - don't have much trouble getting right in the middle of basket.

CONTROL SYSTEM FEEL: Reasonable/good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING: Not done.

EVALUATION NO. 10	CONFIGURATION NO. 2-3F1	PILOT: B	TASK: Formation and gun tracking
τ_R =.45	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS: Target too aggressive. Not used in analysis.	SAFETY PILOT RATING 5	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

No undesirable motions, initial response somewhat slow. Final response fine. Medium good predictability. No overshoots during gross acquisition — fine tracking was problem. Rudder helped during tracking to get pipper motion started.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Formation much easier than tracking (PR=2 or 3). Unpredictable tracking was most difficult and is basis for PR.

EVALUATION NO. 14	CONFIGURATION NO. 2-3F1	PILOT: B	TASK:HUD tracking Flight Phase Cat.A
τ_R =.45	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

No PIO or ratcheting. But saw one bank overshoot each time for bank steps. Heading target moved off a bit as I rolled out. Had to make another correction. Initial response - maybe a little pause before it started. Final response/roll rate fine. Heading not too predictable - one overshoot on rollout. More aggressiveness made overshoot worse. Rudder helped reduce heading overshoot.

CONTROL SYSTEM FEEL:

Maybe a bit sensitive, otherwise fine.

EVALUATION NO. 148	CONFIGURATION NO. 2-3F2	PILOT: B	TASK: Gun tracking

τ_R = .45	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.17s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

No PIO. Initial and final response reasonably good. Predictability not bad. If really aggressive during large inputs I got one big overshoot. Fine tracking. Got that one overshoot during gross acquisition. Little bit of rudder helped - but not required for desired performance.

CONTROL SYSTEM FEEL:

Lateral forces a little high - not a real bother. Displacements fine. Sensitivity adequate.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Not done.

EVALUATION NO. 70	CONFIGURATION NO. 2-3F2	PILOT: B	TASK: Air refueling

$\tau_{R=.45}$	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.17s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No real overshoots. Response not "tight" feeling really. Can definitely feel response build up following an input. But didn't cause overshoot with required aggressiveness level. Maybe could be a bit more precise with small smooth inputs but precision was still fine with larger inputs.

LATERAL POSITION CONTROL:

Did not use rudder - might have helped but I didn't need it.

CONTROL SYSTEM FEEL:

Sensitivity a little low - would have prefered a bit higher, but didn't affect task. Forces/displacements OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 43	CONFIGURATION NO. 2-3F3	PILOT: B	TASK: Formation and gun tracking
$\tau_{R=.45}$	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Definite undesirable motions - PIO any time I tried to make small or large corrections - worse for large - not divergent - but could be. Initial response wasn't too bad. Final response bad - couldn't get constant roll rate because of roll oscillations. Predictability was terrible. Being aggressive made it rapidly much worse. Had to be smooth and slow to keep any precision at all. Gross acquisition was bigger problem than fine tracking - surprised that it stayed in place pretty well on a steady target once I got it in place. Getting to gross acquisition was a problem. Tried rudder - didn't seem to help - probably hurt. Other compensation technique was to reduce aggressiveness.

CONTROL SYSTEM FEEL:

Forces and displacements OK. Lateral force maybe a bit heavier than I would like but acceptable. Didn't like sensitivity - would like higher lateral sensitivity. Maybe my impression of sensitivity is clouded by oscillations.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Random tracking close to PR=9.

HUD TRACKING:

Absolutely atrocious bank tracking if I am aggressive. PR=8. Heading tracking not as difficult.

EVALUATION NO. 89	CONFIGURATION NO. 2-3F3	PILOT: P	TASK: HUD tracking Flight Phase Cat.A

τ_R = .45	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS	SAFETY PILOT RATING 6	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

Couple of substantial overshoots in bank, especially if did bank angle task aggressively. Get more final response than I expected - unpredictable. Much less problem for small fine inputs than for larger inputs. Overshoots more apparent during bank tracking than heading tracking.

CONTROL SYSTEM FEEL:

Forces/displacements - OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

All comments for HUD tracking.

EVALUATION NO. 113	CONFIGURATION NO. 2-3T1F1	PILOT: B	TASK: Gun tracking

τ_R = .45	p/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

Some tendency to PIO. Felt loose. Initial response terrible, but could get final response/roll rate I wanted if I waited long enough. Predictability poor. Aggressiveness hurt precision. Fine tracking poor. Gross acquisition not too bad. Rudder helped. Other compensation technique - perhaps timing of aileron inputs.

CONTROL SYSTEM FEEL:

Lateral sensitivity low for small quick inputs, harmony OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

A poor PR=6.

EVALUATION NO. 172	CONFIGURATION NO. 2-3T2F7	PILOT: P	TASK: HUD tracking Flight Phase Cat.A
τ_R = .45	P/F_{AS} = 18	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{.05s+1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Slight tendency to overshoot bank - but could get desired performance. Initial response good - but had a little trouble predicting final response. Overshot more when I was aggressive. No compensation.

CONTROL SYSTEM FEEL:

Lateral forces light but comfortable. Displacements felt small. Lateral sensitivity on the high side but OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

N/A.

EVALUATION NO. 181	CONFIGURATION NO. 2-3D2	PILOT: B	TASK: Gun tracking

τ_R = .45	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: ζ_{DR} = 0.8	SAFETY PILOT RATING 2	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No PIO or ratcheting - just kind of one slow small overshoot in azimuth pipper position - everytime I rolled out I had to make one more pipper correction. Rudder helped a lot to point aircraft where I wanted it. Didn't seem to point where I wanted as well without rudder. Final response and initial response OK. Predictability degraded a bit by pointing problem. Aggressiveness didn't make any difference. Gross acquisition OK. Problem was in fine tracking - took an extra input to move pipper each time.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 30	CONFIGURATION NO. 2-4	PILOT: G	TASK: Formation and gun tracking

τ_R=.45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Initial and final responses were well coordinated. Wasn't sluggish. Very predictable - could stop it where I wanted to. Could be aggressive and not lose accuracy. Gross acquisition very easy - didn't have to think about roll. Fine tracking same. Roll tracking easier than pitch. No compensation techniques used.

LATERAL FLIGHT PATH CONTROL:

Noticed one overshoot during gross acquisition.

CONTROL SYSTEM FEEL:

Maybe a little light sensitivity right around neutral - got used to it quickly. Roll feel light. Maybe harmony down a bit.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Formation easy/tracking easy.

HUD TRACKING:

Easy, could be aggressive. Maybe give PR=1-2 for bank tracking.

EVALUATION NO. 39	CONFIGURATION NO. 2-4	PILOT: P	TASK: Formation and gun tracking

τ_R = .45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Initial jerkiness in bank angle control. Tended to get too much initial roll rate going so for small inputs I tended to overshoot. For large inputs I tended to overcontrol the bank angle because the initial response was a little bit sensitive/jerky/fast - induced a little bit of ratcheting. Once I got past the initial input, things felt pretty good and I could settle down. I had some problems with the initial part - precision and accuracy. Fine tracking more difficult than gross acquisition because jerkiness doesn't bother gross acquisition. No compensation techniques.

LATERAL POSITION CONTROL:

Formation easier than tracking. Initial jerkiness bothered me somewhat.

CONTROL SYSTEM FEEL:

Forces/displacements OK. Harmony OK. Initial sensitivity felt high in relation to final sensitivity.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Heading tracking not much of a problem. Bank tracking - saw jerkiness/ one overshoot (maybe would give a little better PR).

EVALUATION NO. 17	CONFIGURATION NO. 2-4	PILOT: B	TASK: HUD tracking Flight Phase Cat.A
τ_R = .45	P/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial response was quick, but no problem once I learned it was quick. Final response was fine. It was predictable. No problem even with aggressiveness. Both fine and gross tracking fine. No compensation techniques required.

CONTROL SYSTEM FEEL:

Forces light, but pleasantly light. Displacements OK. Sensitivity on light side but no problem. Harmony fine.

TURBULENCE/CROSSWIND EFFECT ON RATING:

None.

EVALUATION NO. 124	CONFIGURATION NO. 2-4	PILOT: B	TASK: Gun tracking
τ_R = .45	P/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial/final responses fine. Predictability fine. Precision/accuracy good even when aggressive. Gross acquisition no problem at all. Fine tracking a little more difficult - rudder was needed to get really good fine tracking.

LATERAL FLIGHT PATH CONTROL:

Wasn't PR=2 or 1 because pipper placement was a little difficult even though bank angle control was very good.

CONTROL SYSTEM FEEL: Fine.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING: None.

HUD TRACKING (Bank): Had more trouble with gun tracking than with bank tracking. Maybe better PR for bank tracking.

EVALUATION NO. 90	CONFIGURATION NO. 2-4	PILOT: P	TASK: HUD tracking Flight Phase Cat.A
τ_R = .45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Some aileron buzz during evaluation	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Comfortable. No PIO or ratcheting or overshoots. Liked initial and final response - predictable. Performance did not deteriorate even if I was aggressive. Could make big and small corrections well. Did not use any compensation techniques.

CONTROL SYSTEM FEEL:

Maybe a little too sensitive if real aggressive. Forces OK. Displacements OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

All comments are for HUD tracking.

OTHER:

Some aileron buzz during evaluation. Did not compromise simulation fidelity enough however, to affect evaluation.

EVALUATION NO. 46	CONFIGURATION NO. 2-4T1	PILOT: B	TASK: Formation and gun tracking
τ_R = .45	p/F_{AS} = 25	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Definite ratcheting/overshoots - annoying. Not a problem during steady rolls - problem is during roll starting and stopping - got couple of quick overshoots. Initial response much too quick - seemed to take off. Final response/roll rate fine. Predictability for small rapid inputs was terrible. Aggressiveness increased problems - especially for small quick inputs. Fine tracking more of a problem than gross acquisition - ratcheting. Didn't use rudder - couldn't find compensation technique to fix the primary problem - ratcheting.

CONTROL SYSTEM FEEL:

Lateral force felt light - especially during formation. Very sensitive for small inputs - OK for larger inputs. Harmony/displacements OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

PR=4 for tracking, 5 for formation - due to light forces and jerkiness.

HUD TRACKING:

See same problems - ratcheting/overshoots. Give same PR.

EVALUATION NO. 61	CONFIGURATION NO. 2-4T2	PILOT: B	TASK: Air refueling
τ_R = .45	P/F_{AS} = 25	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

One quick overshoot - extremely responsive. Couldn't modulate roll rate - roll rate was either there or it wasn't. Roll rate "stepped" - would have preferred a slower build up of roll rate.

LATERAL POSITION CONTROL:

Had to cut down on aggressiveness to keep precision/accuracy. More aggressiveness hurt predictability. Compensation - slowed down inputs - flew smoothly.

CONTROL SYSTEM FEEL:

Initial lateral forces were very light. Sensitivity too high for this task.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence/directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 208	CONFIGURATION NO. 2-4T2	PILOT: B	TASK: HUD tracking Flight Phase Cat.A
τ_R = .45	p/F_{AS} = 25	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

PIO/ratcheting together - sharp not divergent. Initial response way too fast. Final response/roll rate was OK. Predictability terrible - took off all at once. Aggressiveness hurt precision/accuracy.

CONTROL SYSTEM FEEL:

Lateral forces very light/sensitivity extremely high for small inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 57	CONFIGURATION NO. 2-4T2	PILOT: G	TASK: Air refueling
τ_R = .45	p/F_{AS} = 25	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

Attitude control good for small inputs. Bad for large inputs. Extreme nonlinearity. Small inputs - predictable/nice. Large inputs - not so nice. If not aggressive - easy to put probe in middle of basket. Things go completely haywire if you are aggressive. Again used steady heading sideslip to stay out of slip stream.

LATERAL POSITION CONTROL:

Can make small corrections OK.

CONTROL SYSTEM FEEL:

Lateral sensitivity - on the border line of being too sensitive for small inputs - definitely way too sensitive for large inputs.

HUD TRACKING:

Not done.

EVALUATION NO. 35	CONFIGURATION NO. 2-4T3	PILOT: G	TASK: Formation and gun tracking

τ_R = .45	p/F_{AS} = 25	TIME DELAY: .125	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 9

ROLL ATTITUDE CONTROL:

Lost control of roll rate twice. Definitely in a PIO when I tried to operate around neutral - completely unacceptable. Not as much trouble during formation as during tracking. PIO/overcontrol, not predictable. Aggressiveness makes problem much worse. Fine tracking and gross acquisition not possible - Get in flying trouble during gross acquisition. Don't know any compensation techniques except, for formation, to hold stick very, very lightly.

CONTROL SYSTEM FEEL:

Bad harmony between pitch and roll - roll just too light.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 63	CONFIGURATION NO. 2-4F1	PILOT: B	TASK: Air refueling
τ_R =.45	P/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL

Comments missing

LATERAL POSITION CONTROL:

No overshoots. Could be aggressive. Didn't need any compensation other than rudder for steady heading sideslip

CONTROL SYSTEM FEEL:

Forces/displacements/sensitivity/harmony OK

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 71	CONFIGURATION NO. 2-4F1	PILOT: B	TASK: Air refueling
τ_R =.45	P/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions/overshoots.

LATERAL POSITION CONTROL:

Precise even if aggressive. Predictable. No compensation required.

CONTROL SYSTEM FEEL:

Pleasant.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - turbulence and directional effects from tanker.

HUD TRACKING:

Not done.

EVALUATION NO. 18	CONFIGURATION NO. 2-4F1	PILOT: B	TASK:HUD tracking Flight Phase Cat.A

τ_R =.45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

One overshoot in bank, especially when being aggressive. Initial and final response not too bad, except for that overshoot. Predictability good when maneuvering smoothly, not so good when maneuvering aggressively. Gross acquisition no problem - fine tracking was problem. Rudder didn't help. Only compensation was to change aggressiveness a bit.

CONTROL SYSTEM FEEL:

Forces fine. Displacements OK. Sensitivity OK - as far as response for small input goes. Harmony OK.

TURBULENCE, CROSSWIND EFFECT ON RATING:

None.

OTHER:

Predictability problems.

EVALUATION NO. 179	CONFIGURATION NO. 2-4F2	PILOT: B	TASK: Gun tracking

τ_R = .45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.17s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No PIO/ratcheting. Initial/final response OK. Predictable. Aggressiveness didn't hurt accuracy. Gross acquisition super. Fine tracking good once on target. Pipper seemed to wander around a little bit.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Bank tracking may be PR=2.

EVALUATION NO. 79	CONFIGURATION NO. 2-4F2	PILOT: G	TASK: Air refueling

τ_R = .45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.17s+1}$	REMARKS: Anomalous PR, overly aggressive offset. Not used in analysis	SAFETY PILOT RATING 5	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Tendency to overcontrol bank angle/overshoots. Initial/final response not linear, especially for large inputs. Predictability not there for large inputs. Everything deteriorates rapidly as aggressiveness increases. Feeling of what airplanes doing goes away. Some wing rock moving towards basket.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional.

OTHER:

PR=7 mainly due to aggressive offset maneuver. Would give PR=3 for smooth flying plug in phase.

HUD TRACKING:

Not done.

EVALUATION NO. 166	CONFIGURATION NO. 2-4F2	PILOT: B	TASK: Gun tracking

τ_R = .45	P/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.17s+1}$	REMARKS: Conf. in doubt. Not used in analysis.	SAFETY PILOT RATING 6	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Some tendency towards PIO - smooth - fairly high frequency. 2 or 3 overshoots didn't diverge. Spongy - started off slow then took off. Predictability was poor - never could stop it right where I wanted - or start it like I wanted. Being aggressive hurt precision and accuracy. Gross acquisition was degraded - but primary problem was fine tracking. Oscillations would stop if I didn't make any inputs - but would start again as soon as I made an input. Rudder didn't help.

CONTROL SYSTEM FEEL:

Lateral sensitivity low initially. Forces/displacements OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 72	CONFIGURATION NO. 2-4F2	PILOT: B	TASK: Air refueling

τ_R = .45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.17s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 1

ROLL ATTITUDE CONTROL:

No overshoots or undesirable motions. Precise and accurate even if aggressive. No compensation required. Very predictable.

CONTROL SYSTEM FEEL:

Fine.

OTHER:

Not really that much better than some other configurations I have rated PR=2.

HUD TRACKING:

Not done.

EVALUATION NO 199	CONFIGURATION NO. 2-4F2	PILOT: P	TASK: HUD tracking Flight Phase Cat.A

τ_R = .45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.17s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Little tendency to overshoot if aggressive. Predictability good for smaller inputs. Not quite as good for larger inputs.

CONTROL SYSTEM FEEL:

Good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 64	CONFIGURATION NO. 2-4F2	PILOT: B	TASK: Air refueling

τ_R = .45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.17s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

LATERAL POSITION CONTROL:

No overshoots. Could be aggressive and still be precise. No compensation required other than rudder. A little sponginess in controls - not quite as sharp and crisp - but still very predictable. Task easy.

CONTROL SYSTEM FEEL:

Forces and displacements OK. Harmony OK. Wasn't quite as sensitive as some other configurations. Put in an input and it seemed to take a little while. Felt like I had a heavier/bigger airplane - wasn't a problem as far as ability to place the probe - that was very nice.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

EVALUATION NO. 94	CONFIGURATION NO. 2-4F3	PILOT: B	TASK: Formation and gun tracking
$\tau_R = .45$	$p/F_{AS} = 25$	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

PIO in roll - slow - not ratcheting. 2 or 3 overshoots following a large bank angle change. Sloppy, slow to get started. Didn't stop where I wanted it to at all. Initial response slow. Final response/roll rate fine. Problem's in starting and stopping roll rate - predictability very poor. More aggressiveness made overshoots bigger/more of them. Fine tracking and gross acquisition both difficult - couldn't do either adequately. Compensation techniques - none for formation - rudders helped gun tracking.

LATERAL POSITION CONTROL:

Could keep aircraft in formation position with a lot of work.

CONTROL SYSTEM FEEL:

Lateral forces a bit heavy getting started and stopped, nice and light during steady rolls. Not too bad. Displacement - seemed to use more laterally - maybe overdriving it.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

A poor 7 overall. Even formation was bad. Maybe would give PR=5 for formation alone.

HUD TRACKING:

Would give a PR=7 for bank tracking - many overshoots - couldn't stop them.

EVALUATION NO. 60	CONFIGURATION NO. 2-4F3	PILOT: B	TASK: Air refueling

τ_R=.45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Overshoots - a lot of them - worried about PIO. Oscillations at slower frequency than other "ratcheting" oscillations. Compensation techniques - vary aggressiveness, vary stick grasp - no help.

LATERAL POSITION CONTROL:

Had position overshoots even when I reduced aggressiveness and held stick very lightly - dangerous if plugged in. Didn't feel I had enough accuracy to plug in.

CONTROL SYSTEM FEEL:

Lateral forces initially were light - seemed heavier for steady state, but within reason.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

OTHER:

Didn't plug in because of poor flying qualities. Maybe could have in an emergency.

HUD TRACKING:

Not done.

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LATERAL FLYING QUALITIES OF HIGHLY AUGMENTED FIGHTER AIRCRAFT, --ETC(U)
MAR 82 S J MONAGAN, R E SMITH, R E BAILEY F33615-79-C-3618
UNCLASSIFIED CALSPAN-6645-F-8-VOL-2 AFWAL-TR-81-3171-VOL-2 NL

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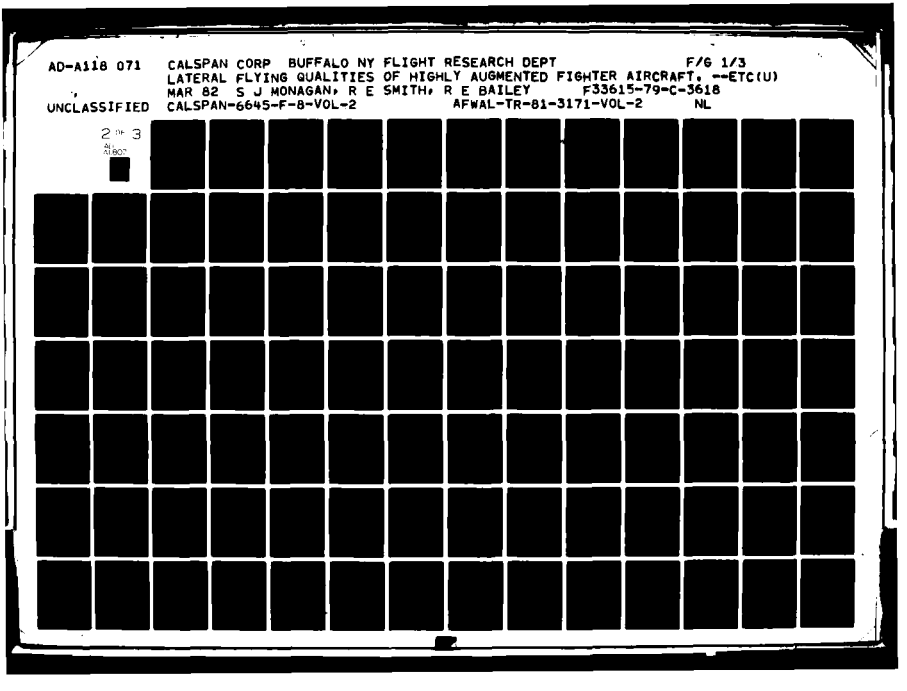


EVALUATION NO. 173	CONFIGURATION NO. 2-4F3	PILOT: P	TASK: HUD tracking Flight Phase Cat.A
τ_R = .45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Definite tendency to PIO during aggressive bank tracking. Something wrong with initial response - makes me PIO for small and large corrections - obviously a function of aggressiveness. Not an obvious delay - but something is hurting predictability.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

N/A.

EVALUATION NO. 109	CONFIGURATION NO. 2-4T1F1	PILOT: P	TASK: Formation and gun tracking
τ_R = 0.45	p/F_{AS} = 25	TIME DELAY: .075	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Problems in random tracking. Tendency to overshoot and PIO. Tended to get more than I expected in final response. A little problem with initial response too, but final response was unpredictable. Things got worse with aggressiveness. Tendency to overcontrol even in fine track.

CONTROL SYSTEM FEEL:

Forces/displacements - OK. Airplane seemed to have a lag and then really came on - sensitivity not good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING: None.

OTHER: Formation was easier but definitely unpleasant responses there too (formation PR=6).

HUD TRACKING: HUD track same as gun track (PR=7).

EVALUATION NO. 103	CONFIGURATION NO. 2-4T2F1	PILOT: B	TASK: Formation and gun tracking
τ_R =0.45	p/F_{AS} = 25	TIME DELAY: .105	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 9	EVAL PILOT RATING 9

ROLL ATTITUDE CONTROL:

Controllable - barely; certainly not adequate. Closest one I've had to losing control. Undesirable motions definitely; a PIO, sometimes divergent. Initial response kind of took off on me a little bit - it built up, not like a sudden step increase but it did build up fast. Final response was unpredictable. Predictability was atrocious - real problem. Had to back off of aggressiveness to get any precision. Large oscillations during gross acquisitions. Fine tracking terrible. Rudder wouldn't help. Compensation was not to be aggressive.

CONTROL SYSTEM FEEL:

Forces/displacements - OK. Sensitivity was too high.

EVALUATION NO. 134	CONFIGURATION NO. 2-4N2	PILOT: B	TASK: Gun tracking
τ_R = .45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Nonlinear 2

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

No PIO - on edge of ratcheting - not a problem. Initial response quite fast for a given input. Final response/roll rate fine. Predictability pretty good but not perfect. Problem was it took off a little quick for a given input. No real loss of precision/accuracy with aggressiveness. Fine and gross tracking performance about the same. Rudder didn't help. Compensation - learned to handle quick initial response.

CONTROL SYSTEM FEEL:

Lateral forces a little light getting started but well within reason - minor deficiency that led to PR=4.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Wasn't holding stick hard because of intermittant aileron buzz - may have also been a compensation technique.

HUD TRACKING:

Found I was having trouble stopping on desired bank angle - bit of a step response.

EVALUATION NO. 160	CONFIGURATION NO. 2-4T2N2	PILOT: B	TASK: Gun tracking
τ_R = .45	P/F_{AS} = 25	TIME DELAY: .105	COMMAND GAIN: Nonlinear 2
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Couple of quick overshoots. Initial and final response OK. Predictability reasonable but got a bit of an overshoot, particularly in fine tracking. Gross acquisition was no problem - fine tracking was a problem. More aggressive I was the more it tended to overshoot. Rudder didn't help.

CONTROL SYSTEM FEEL:

Forces/displacements OK. Initial lateral sensitivity a bit high.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 147	CONFIGURATION NO. 2-4T2N2	PILOT: B	TASK: Gun tracking
τ_R = .45	P/F_{AS} = 25	TIME DELAY: .105	COMMAND GAIN: Nonlinear 2
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Little bit of oscillation - incipient PIO - annoying. Moves pipper a bit - not really sharp. Final response fine. A little slow getting going initially Predictability fair. Had little "squiggle" in there whether I was aggressive or not. Problem was in fine tracking - not in gross acquisition. Annoying - but could still track reasonably well. Couldn't find a compensation technique in time available.

CONTROL SYSTEM FEEL:

Forces/displacements fine. Lateral sensitivity maybe a little bit low.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Not done.

EVALUATION NO. 186	CONFIGURATION NO. 2-4F1N2	PILOT: B	TASK: Gun tracking
τ_R =0.45	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Nonlinear 2
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Fine tracking was good. No undesirable motions. Some overshooting/maybe 1 but not building. Final response OK; initially a little slow. Predictability - large response - didn't stop when I wanted it, but wasn't enough to seriously degrade predictability. Tracking - gross acquisition started OK. When it stopped, it seemed pipper was always off either left or right - that took another correction. Fine tracking great/aggressiveness made no difference. Compensation - yes, rudder helped - desired performance/fine tracking good with rudder.

CONTROL SYSTEM FEEL:

Lateral forces OK. Sensitivity - within reason but on low side.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Could get desired performance with rudder - PR=4.

EVALUATION NO. 159	CONFIGURATION NO. 2-4T1F1N2	PILOT: B	TASK: Gun tracking

τ_R = .45	p/F_{AS} = 25	TIME DELAY: .075	COMMAND GAIN: Nonlinear 2

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

PIO - not divergent, but enough overshoots so I didn't feel I have full command of the airplane. No apparent delay in initial response. Final response OK. Predictability very poor - planned on stopping motion but it didn't stop. Backing off on aggressiveness helped - but not enough - never got adequate performance. Gross acquisition was not as bad as fine tracking - got so many overshoots. Rudder didn't help. Backing off on task was only compensation technique.

CONTROL SYSTEM FEEL:

Forces/displacements/sensitivity OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 42	CONFIGURATION NO. 3-2	PILOT: B	TASK: Formation and gun tracking
τ_R=.25	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

No PIO or ratcheting. Final response/roll rate fine. Something about initial response bothered me. Predictability not as good for fine changes as for larger changes, but still fairly good. Being aggressive did help precision. Rudder did help, particularly during random tracking.

CONTROL SYSTEM FEEL:

Fine.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Between PR=4 and 5. Desired vs. adequate performance.

HUD TRACKING:

Small roll rate changes superimposed on main one "smooth ratcheting". A little worse than primary tasks. Maybe PR=5.

EVALUATION NO. 111	CONFIGURATION NO. 3-2	PILOT: P	TASK: Formation and gun tracking
τ_R =0.25	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial response good. Final response predictable. Not a function of aggressiveness - felt comfortable during aggressive and non-aggressive tracking. No difference between fine tracking and gross acquisition. No compensation. No tendency to overshoot.

CONTROL SYSTEM FEEL:

Forces comfortable. Sensitivity/harmony/displacements - all OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 51	CONFIGURATION NO. 3-2	PILOT: G	TASK: Aerial refueling
τ_R=0.25	P/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Have to give this one a little worse rating because for some reason it felt a little bit sensitive around neutral; either that, or I felt I needed to have my hand moving thru neutral (back and forth) to really tighten the aircraft attitude - not desirable; definite pilot compensation required but I could do the task. PR=4 at least; possibly a PR=5 because it was a bother. Little bit of undesirable motion as I moved my hand thru neutral. Initial response a little bit sluggish thru neutral (deadband). However once out of neutral, it was predictable. I could get aggressive with control and fly the aircraft very accurately although kind of "lumpy" - not very smooth. Compensation same as other (#50) except moving my hand thru neutral. No real overshoots. Small changes were kind of contaminated by that "rattling".

CONTROL SYSTEM FEEL:

Felt a lack of sensitivity around neutral. Harmony was alright I guess.

HUD TRACKING:

Not done.

EVALUATION NO. 44	CONFIGURATION NO. 3-3	PILOT: B	TASK: Formation and gun tracking
τ_R = .25	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Definite ratcheting. Would die out during steady rolls. Degraded predictability for small quick corrections - didn't get what I expected to at all. Aggressiveness was a problem in that you got ratcheting each time you put in an input - so the more inputs the more ratcheting. Large inputs in themselves were not a real problem. Gross acquisition not a problem. Small corrections during fine tracking were a problem. Compensation techniques - rudder didn't help. Have to back off on aggressiveness a long way before that technique would help. Control not in question - ratcheting just annoying.

LATERAL POSITION CONTROL:

Could hold formation position well but didn't like ratcheting.

CONTROL SYSTEM FEEL:

Lateral force seemed light for initial input - it just took right off. Force for larger/steady input was pleasant. Sensitivity high for small corrections.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Had to decide between PR=4 and 5. Choose PR=5 because of objectionable deficiencies (ratcheting) rather than strict performance criteria.

HUD TRACKING:

Would rate HUD bank tracking the same, PR=5.

EVALUATION NO. 86	CONFIGURATION NO. 3-3	PILOT: G	TASK: Air refueling
τ_R =.25	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Undesirable motions - unpredictable oscillations - funny. "Well damn PIO." Never knew when it would start. Aggressiveness didn't really degrade performance too much. Compensation technique - be easy with it. Wasn't willing to be super aggressive.

CONTROL SYSTEM FEEL:

Lateral forces very light. Sensitivity too high. Displacements kind of small.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 119	CONFIGURATION NO. 3-3	PILOT: P	TASK: Gun tracking
τ_R =0.25	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Desired performance attained - but jumpy response. Initial abruptness was undesirable, otherwise a good aircraft. Did not really develop into ratcheting or overshoots. Comfortable otherwise. Predictability pretty good. Aggressiveness didn't make much difference - jumpy for all inputs. Gross acquisition was easier part - fine tracking bothered more by jumpiness. Used a little rudder to smooth things out.

CONTROL SYSTEM FEEL:

Forces/displacements - good. Sensitivity - good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 96	CONFIGURATION NO. 3-3	PILOT: B	TASK: Formation and gun tracking
τ_R = .25	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Intermittent aileron "buzz" during this evaluation. Not used in analysis	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No undesirable motions. Not real quick in starting roll, but not too bad. Final response OK. Predictability pretty good. Aggressiveness hurt a bit - could be more precise if I was less aggressive. Gross acquisition fine. Last few corrections to get pipper on target were tough. Once on target I could keep it there. Compensation - may have used a bit of rudder. Also holding stick lightly, especially to stop aileron buzz.

CONTROL SYSTEM FEEL:

Lateral sensitivity a little low, but didn't affect performance much.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

A poor "3". Give same PR for formation as for gun tracking.

HUD TRACKING:

Don't know where I got previous "slow to get started" comments. This gets going right away - probably would still give PR=3 though.

EVALUATION NO. 200	CONFIGURATION NO. 3-3	PILOT: P	TASK: HUD tracking Flight Phase Cat.A
τ_R =.25	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

Liked it/comfortable. Predictable. Could be precise even if aggressive.

CONTROL SYSTEM FEEL:

Good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 104	CONFIGURATION NO. 3-3	PILOT: B	TASK: Formation and gun tracking
τ_R =0.25	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Controllable, adequate but not satisfactory without improvement. Got adequate performance. Small tendency to ratchet - annoying. Initial response takes off quickly. Final response OK, got roll rate I wanted. Predictability hurt by small ratcheting. More aggressive - worse precision. Fine tracking was where I noticed it. Saw ratchet in gross but not a factor. Compensation - rudder didn't help; no compensation helped.

CONTROL SYSTEM FEEL:

Too sensitive - on high side of usable.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

No turbulence.

OTHER:

Might give it a PR=4 for formation.

EVALUATION NO. 115	CONFIGURATION NO. 3-3T2	PILOT: B	TASK: Gun tracking
τ_R = .25	p/F_{AS} = 18	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Very definite ratcheting - caused two or three overshoots each time I made a correction. I could feel ratcheting even during an attempted steady roll. Initial response much too quick - put an input in and got response immediately - no buildup at all. Final response even poor - ratcheting superimposed on final roll rate. Predictability poor - took off like crazy. Actual pipper placement not bad - wing rocking doesn't hurt pipper position since no pendulum effect. No compensation worked.

CONTROL SYSTEM FEEL:

Lateral forces light. Lateral sensitivity high.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Rating based more on "deficiencies require improvement" than on performance - performance not too bad.

HUD TRACKING:

See same ratcheting/quick sharp overshoots.

EVALUATION NO. 73	CONFIGURATION NO. 3-3T3	PILOT: B	TASK: Air refueling
τ_R = .25	p/F_{AS} = 18	TIME DELAY: .125	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Wing rock - kept up after plug in (always has stopped with other configurations). Wing rock present even when just maintaining pre-contact position - wing rock increased as I approached the basket. Could do task with reasonable precision - but had wing rock going all the time - workload problem rather than precision problem primarily. Problem got worse with increased aggressiveness. Couldn't find any compensation technique which would work.

CONTROL SYSTEM FEEL:

Initial input seemed light. Sensitivity high initially. Final force/response OK.

OTHER:

Could get desired performance but wo.kload is intolerable and deficiencies require improvement.

HUD TRACKING:

Not done.

EVALUATION NO. 32	CONFIGURATION NO. 3-3F1	PILOT: G	TASK: Formation and gun tracking
τ_R =.25	P/F_{AS} =18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 4½	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Almost ratcheting - not really a PIO. Predictability for input away from neutral was good - not quite as good for inputs near neutral. I can't roll the airplane real slowly when I want to. Gross acquisition OK. Fine tracking degraded by sensitivity. Have trouble around zero roll rate.

CONTROL SYSTEM FEEL:

Sensitive around neutral. Harmony better away from neutral than around neutral.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 55	CONFIGURATION NO. 3-3F1	PILOT: G	TASK: Aerial refueling
τ_R =0.25	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Adequate but not really desirable - it takes pilot compensation; I think I'd have a lot of trouble chasing drogue in any kind of turbulence. Hard to hold attitude - felt as though overcontrolling the airplane all the time. Just a little too sensitive for medium and small inputs; don't know about big ones. PR=4, maybe 5. Attitude control was OK but not super, could hold it fairly close to where I want it but no confidence. 85% predictable. A couple of minor overshoots. Not real precise for all levels of aggressiveness.

CONTROL SYSTEM FEEL:

Almost over sensitive.

HUD TRACKING:

Not done.

EVALUATION NO. 66	CONFIGURATION NO. 3-3F3	PILOT: B	TASK: Air refueling

τ_R = .25	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

One big and one small overshoot for a single input. Especially on offset maneuver.

LATERAL POSITION CONTROL:

Aggressiveness hurt precision and accuracy. Rudders helped a lot for compensation. Predictability was down - put an input in - response takes a while.

CONTROL SYSTEM FEEL:

Lateral control felt rather spongy. Sensitivity a little low - didn't get a response right away. Harmony/displacements OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

OTHER:

Doing task without rudder might increase workload beyond tolerable level.

HUD TRACKING: Not done.

EVALUATION NO. 135	CONFIGURATION NO. 3-3F3	PILOT: B	TASK: HUD tracking Flight Phase Cat.A

τ_R = .25	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

2 or 3 overshoots - beginning of PIO. Not snappy getting started. Response took a while to build up. Noticeable amount of time. Final response/ roll rate fine. Predictability not good. Seemed to get about same number of overshoots whether I was less or more aggressive - so aggressiveness didn't make as much difference as expected. Rudder didn't seem to help. Spongy response.

CONTROL SYSTEM FEEL:

Lateral forces - not excessive.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

All comments are for HUD tracking.

EVALUATION NO. 149	CONFIGURATION NO. 3-3F4	PILOT: B	TASK: Gun tracking
τ_R = .25	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.5s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 5½

ROLL ATTITUDE CONTROL:

Several overshoots - spongy. 2 or 3 overshoots before I could damp it out. Certainly not ratcheting. Initial response felt sluggish - had to overdrive it. Final response/roll rate was OK. Predictability poor. More aggressive I was the worse the overshoots were. If I flew very smoothly I didn't notice them so much. Sluggish during gross acquisition and overshoots, during fine tracking - neither good. Rudder helped getting motion started.

CONTROL SYSTEM FEEL:

Lateral forces high. Felt like quite a bit of lateral motion - particularly for fine tracking. Sensitivity low - sluggish. Prefer lighter aileron force.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Would give a PR=6 for bank tracking.

HUD TRACKING:

Not done.

EVALUATION NO. 80	CONFIGURATION NO. 3-3F4	PILOT: G	TASK: Air refueling

τ_R = .25	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.5s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Problem seemed to be more in trying to stop the attitude where I wanted it rather than getting motion started. Stopping attitude precisely where I wanted it was a bit hard, especially if I was aggressive. Could rattle stick back and forth and nothing would happen - attitude wouldn't change. Not much undesirable motion. Felt like I was leading stick input. Predictability OK for small stick inputs. Poor for larger inputs. Accuracy degraded with aggressiveness, especially during offset maneuver. Compensation - have to be somewhat non-aggressive.

LATERAL POSITION CONTROL:

I could control position very well once I stabilized behind basket but didn't feel quite right.

CONTROL SYSTEM FEEL:

Small slow lateral stick motion gave same aircraft response as large stick motion. Forces/displacements OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 201	CONFIGURATION NO. 3-3F5	PILOT: P	TASK: HUD tracking Flight Phase Cat.A
τ_R = .25	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Tendency to overcontrol. 1 or 2 overshoots. First large initial response not there - slow onset. As a result the final response is not very predictable. Precision and accuracy degraded with increased aggressiveness and larger inputs.

CONTROL SYSTEM FEEL:

Initial lateral force quite large. Even final lateral force larger than I like. Some pitch/roll harmony problems.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Felt uncomfortable with this airplane.

EVALUATION NO. 125	CONFIGURATION NO. 3-3T1F1	PILOT: B	TASK: Gun tracking
τ_R = .25	P/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Beginning of PIO. Several overshoots - not sharp/not ratcheting. Inputs seemed spongy. Final response/roll rate OK. Predictability very poor. More aggressive made precision/accuracy quickly very poor - have to be very non-aggressive to avoid PIO. Problem is in fine tracking - really bad. Overshoots didn't hurt gross acquisition as much. Rudders didn't help primary problem - PIO.

CONTROL SYSTEM FEEL:

Forces OK - maybe lateral forces a bit heavy initially. Lateral sensitivity a bit low initially.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Number of overshoots.

EVALUATION NO. 162	CONFIGURATION NO. 3-3D2	PILOT: B	TASK: Gun tracking

τ_R = .25	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: ζ_{DR} = 0.8	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial response fine/final response fine. Very predictable. Aggressiveness didn't detract from accuracy. Gross acquisition and fine tracking good.

CONTROL SYSTEM FEEL:

Good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 182	CONFIGURATION NO. 3-3D2	PILOT: B	TASK: Gun tracking

τ_R = .25	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: ζ_{DR} = 0.8	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial/final response fine. Noticed initial motion was faster than some other configurations - but not objectionable. Predictable. Aggressiveness didn't make any difference with precision. Gross acquisition and fine tracking OK. Rudder didn't seem to help.

CONTROL SYSTEM FEEL:

Lateral sensitivity a bit high but OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 203	CONFIGURATION NO. 3-3T1D2	PILOT: P	TASK: HUD tracking Flight Phase Cat.A

τ_R = .25	p/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Heading and Bank Tracking; ζ_{DR} = 0.8	SAFETY PILOT RATING 2	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No real undesirable motions. Maybe a little tendency to overcontrol if I was aggressive - reason for PR = 3. Predictability relatively good. Aggressiveness degraded precision a little.

CONTROL SYSTEM FEEL:

Good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 205	CONFIGURATION NO. 3-3T1D2	PILOT: P	TASK: HUD tracking Flight Phase Cat.A
τ_R = .25	p/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Bank tracking only; ζ_{DR}= 0.8	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

Pretty well liked it. Maybe a little jumpiness for aggressive inputs. Smooth/predictable. Size of input not a factor.

CONTROL SYSTEM FEEL:

Comfortable.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 183	CONFIGURATION NO. 3-3T2D2	PILOT: B	TASK: Gun tracking

τ_R = .25	p/F_{AS} = 18	TIME DELAY: .08	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: $\zeta_{DR} = 0.8$	SAFETY PILOT RATING 6	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

Ratcheting - no slow roll rate buildup. Tendency towards PIO - not gross. Made 2/3 inputs to stop motion. Initial response quick - put input in and got response right away. Final response/roll rate OK. Predictability poor because of starting and stopping jerks. Aggressiveness hurt fine tracking - but not gross acquisition. Rudder didn't help. Only compensation seemed to be to just work hard at it.

CONTROL SYSTEM FEEL:

Initial lateral force seemed light. Sensitivity very high.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Objectionable but tolerable deficiency - only adequate performance.

EVALUATION NO. 191	CONFIGURATION NO. 3-4	PILOT: B	TASK: Gun Tracking
$\tau_R = 0.25$	$p/F_{AS} = 25$	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Minor annoying deficiency. No undesirable motions but it did take off on me. Initial response took off pretty smartly; wasn't square corner but was sensitive. Final response - OK. Predictability impaired a bit by getting faster roll rate than expected. Aggressiveness did not bother accuracy. Could detect build up of roll rate. Gross acquisition - no problem. Fine tracking - no problem either.

CONTROL SYSTEM FEEL:

Lateral forces felt light initially, fine steady state. Sensitivity - too sensitive.

OTHER:

Debated between PR = 3 and PR = 4.

EVALUATION NO. 33	CONFIGURATION NO. 3-4	PILOT: G	TASK: Formation and gun tracking
$\tau_R = .25$	$p/F_{AS} = 25$	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Could control things well if I held the stick very lightly but it took a lot of effort. At more than 1g it was all over. Initial response with light stick touch was pretty good. Predictability was zero - overcontrol/ overshoots. The more aggressive I got - the worse the oscillation got. Only compensation technique was to let go - or use finger touch only.

CONTROL SYSTEM FEEL:

Lateral force very light - too sensitive. Displacements OK.

OTHER:

Fine tracking difficult due to overcontrolling.

HUD TRACKING:

Saw basically same problem on HUD tracking.

EVALUATION NO. 54	CONFIGURATION NO. 3-4	PILOT: G	TASK: Aerial refueling
τ_R=0.25	P/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

This configuration I did not like - couldn't do the task but the aircraft was controllable PR=8 possible 9. Undesirable motions. Primarily structural feedback(?) - not sure that if structural feedback weren't there that it would be over sensitive anyway. Very predictable in that I would get into a high frequency lateral oscillation. Lots of overshoots and usually continuous. Could not be precise with this configuration. Feedback oscillations increased with aggressiveness.

CONTROL SYSTEM FEEL:

Overly sensitive. Harmony? Couldn't tell you anything about it.

HUD TRACKING:

Not done.

EVALUATION NO. 212	CONFIGURATION NO. 3-4	PILOT: B	TASK: HUD tracking Flight Phase Cat.A
τ_R =.25	P/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

No PIO, no ratcheting - one small overshoot in bank angle, and one fairly large overshoot in heading. Initial response very responsive. Predictability - bank angle didn't stop where I expected it to. Aggressiveness made it worse.

CONTROL SYSTEM FEEL:

Lateral forces light and sensitivity high.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 136	CONFIGURATION NO. 3-4	PILOT: B	TASK: HUD tracking Flight Phase Cat.A

τ_R = .25	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Quick starting and stopping of roll rate. Initial response very sharp/fast. Final response/roll rate fine. Predictability hurt by sharp takeoff. Aggressiveness didn't hurt too much. If I was very aggressive during bank tracking I wouldn't roll out exactly on desired bank angle - have to make a second correction. When less aggressive I could roll out exactly on bank angle. Compensation - flying smoothly helped small corrections.

CONTROL SYSTEM FEEL:

Lateral force very light initially. Lateral sensitivity high, especially for small quick inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING: None.

OTHER:

Annoying deficiency - quick start and stop of roll rate.

HUD TRACKING:

All comments are for HUD tracking.

EVALUATION NO. 101	CONFIGURATION NO. 3-4T2	PILOT: P	TASK: Formation and gun tracking
τ_R = .25	p/F_{AS} = 25	TIME DELAY: .105	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Lots of ratcheting - abrupt initial response - head knocking. Made getting a final smooth response almost impossible. Was bad all the time (formation as well as tracking) so wasn't a function of aggressiveness. Jerkiness more noticeable in fine tracking than gross acquisition. Didn't use rudder.

LATERAL POSITION CONTROL:

Tendency to overshoot in formation - a function of aggressiveness. Didn't feel comfortable but could get adequate formation performance.

CONTROL SYSTEM FEEL:

Lateral force light for initial response. Very sensitive laterally initially.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Rating based on jumpiness not being tolerable, despite performance.

HUD TRACKING (Bank):

Initial response way too jumpy/sensitive - but could get bank angle I wanted - not bad performance.

EVALUATION NO. 49	CONFIGURATION NO. 3-4F1	PILOT: B	TASK: Formation and gun tracking
τ_R = .25	P/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial response a bit sluggish. Final response fine. Was predictable - particularly for formation. Aggressiveness helped - in fact had to be aggressive to get desired performance. Fine tracking easy. Gross acquisition harder. Rudders helped - moved pipper quicker. Roll rate itself wasn't that sluggish - it was my ability to move the pipper that was sluggish.

CONTROL SYSTEM FEEL:

Lateral forces felt higher, but within limits. Displacements OK. Maybe a bit low in sensitivity for gross acquisition. OK otherwise.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Would give PR=2 for formation. Gross acquisition a poor 3.

EVALUATION NO. 75	CONFIGURATION NO. 3-4F1	PILOT: B	TASK: Air refueling
τ_R = .25	P/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No overshoots/undesirable motions. Could be aggressive and still be precise and accurate. Didn't have quite the same predictability as some configurations - not quite as tight - but no compensation was required.

LATERAL POSITION CONTROL:

Offset maneuver is easy to predict - knew quickly how much to lead it - not much. Very easy to get desired performance.

CONTROL SYSTEM FEEL:

Fine.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 74	CONFIGURATION NO. 3-4F3	PILOT: B	TASK: Air refueling

τ_R = .25	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.30s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Not real bad - but did have overshoots - maybe one big one and a couple of wing rocks. A little slow to get started and slow to stop. During aggressive side step, overshoots were more apparent than when just maintaining position. Predictability rather poor primarily for large bank angle changes. Compensation technique - slow down input. Couldn't be too aggressive.

CONTROL SYSTEM FEEL:

Lateral forces felt a bit high but OK. Sensitivity was low for lateral large inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

OTHER:

Deficiency might be a little more than "minor and annoying" but will stick with PR=4.

HUD TRACKING:

Not done.

EVALUATION NO. 81	CONFIGURATION NO. 3-4F4	PILOT: G	TASK: Air refueling
$\tau_R = .25$	$P/F_{AS} = 25$	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.5s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

For large aggressive bank angle changes can't stop aircraft where I want to - aircraft keeps going for a little bit. Once stabilized behind basket I could control aircraft well - good attitude control/no undesirable motions. No problem for small short inputs - but have problem when leave input in - overcontrol bank angle. Predictability good for small inputs - worse for large inputs.

LATERAL POSITION CONTROL:

Good position control once stabilized behind basket.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

OTHER:

PR=4 mainly for more aggressive offset maneuver. Would give PR=2 for close in stabilized part of task.

HUD TRACKING:

Not done.

EVALUATION NO. 213	CONFIGURATION NO. 3-4F4	PILOT: B	TASK: HUD tracking Flight Phase Cat.A
τ_R = .25	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.5s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Definite PIO. Maybe divergent if aggressive. Initial response not too fast. Final response/roll rate OK, but predictability terrible. Had no idea how much I was going to get. And then when I wanted to stop - had no idea when it was going to stop. More aggressive I was the worse it got - oscillations kept going. Compensation - try to fly open loop.

CONTROL SYSTEM FEEL:

Sensitivity low for initial input - then built up.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 97	CONFIGURATION NO. 3-4F5	PILOT: B	TASK: Formation and Gun Tracking
τ_R = .25	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Definite PIO. Once it was divergent - otherwise takes a lot of oscillations to damp out. Final roll rate OK. Initial response terrible. Predictability attrocious. Couldn't tell what response I would get for a given input - caused large overshoots. More aggressive I was worse precision got. But wasn't very precise when I was not aggressive. Had large overshoots for gross acquisition and fine tracking. Rudder didn't help significantly.

CONTROL SYSTEM FEEL:

Forces not too bad. Moving stick a lot to get going. Appeared if lateral inputs were a lot bigger. But displacements OK for steady rolls. Initial lateral sensitivity low, spongy.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER: Formation and gun tracking both PR=8 - worried about control.
HUD TRACKING: Would give a PR=8 for this as well - marginal control.

EVALUATION NO. 170	CONFIGURATION NO. 3-4T1F1	PILOT: B	TASK: Gun tracking

τ_R = .25	P/F_{AS} = 25	TIME DELAY: .075	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

PIO - fairly high frequency - not ratcheting. Initial response a little slow but final response very large - spoiled predictability. More aggressive I was the worse precision and accuracy were/by quite a bit. Could be pretty accurate with small smooth inputs. Fine tracking was the big problem, although gross acquisition was also poor. Rudder didn't help. Only compensation technique I found was to back off on task.

CONTROL SYSTEM FEEL:

Forces/displacements OK. Initial sensitivity low - final sensitivity high.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

A poor PR=7.

HUD TRACKING:

Overshoots - but not out of control.

EVALUATION NO. 107	CONFIGURATION NO. 3-4T2F1	PILOT: B	TASK: HUD tracking Flight Phase Cat.A
τ_R =0.25	p/F_{AS} = 25	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Control in question. PIO's/overshoots. High initial response. Final response - OK. Predictability - atrocious, non-existant almost. Aircraft took off quickly at much higher roll rate than I expected, and when I stopped it, it stopped too quickly. More aggressive I was the worse it got. Could track ramp better than steps.

CONTROL SYSTEM FEEL:

Forces felt real, real light, especially initially. Sensitivity - too sensitive. Harmony OK (a little lighter in pitch, if anything).

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

None.

EVALUATION NO. 48	CONFIGURATION NO. 3-4T2F1	PILOT: B	TASK: Formation and gun tracking
τ_R =.25	p/F_{AS} = 25	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS: Configuration in doubt. Not used.	SAFETY PILOT RATING 6	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

Definite ratcheting - very quick/very sharp. Initial response - takes off quickly - final response fine. Get a roll stepping action. Not predictable for small quick corrections. Larger/slower corrections better. More aggressiveness made it worse - particularly with small quick inputs. Fine tracking was harder than gross acquisition. Rudder didn't help - roll ratcheting.

CONTROL SYSTEM FEEL:

Biggest complaint is high lateral sensitivity for small corrections. Initial lateral force felt very light. Long term roll force OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 37	CONFIGURATION NO. 3-4N1	PILOT: G	TASK: Formation and gun tracking
τ_R =.25	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Nonlinear 1

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

A little sloppy. Some undesirable motions. Initial and final response was predictable. Fine tracking was harder than gross acquisition - which wasn't too difficult. Compensation technique - rested my hand on my knee next to the stick, or controlled airplane with fingertips only. No real difference small vs. large changes.

CONTROL SYSTEM FEEL:

Felt a lack of harmony between roll and pitch

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 69	CONFIGURATION NO. 3-4N1	PILOT: B	TASK: Air refueling
τ_R =.25	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Nonlinear 1

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Didn't feel precise = "wallowing." Had some overshoots - annoying - but didn't really affect task.

LATERAL POSITION CONTROL:

Performance better than I expected considering the flying qualities characteristics.

OTHER:

Performance alone might get a PR=4, but deficiencies are worse than minor/annoying.

HUD TRACKING:

Not done.

EVALUATION NO. 161	CONFIGURATION NO. 3-4N2	PILOT: B	TASK: Gun tracking

τ_R = .25	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Nonlinear 2

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4½

ROLL ATTITUDE CONTROL:

No PIO or ratcheting - but aircraft roll rate seemed to respond in a step manner. Put a small input in - got response immediately - lost some predictability. Much too rapid an initial response. Final response was fine. Felt jerky during fine tracking - annoying. Gross acquisition no problem. Could keep pipper close to where I wanted it though. But was annoyed by being beaten around. Only compensation - kept feeling for where zero stick input was.

CONTROL SYSTEM FEEL:

Initial lateral forces very light - final force fine. Much too sensitive for small lateral inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING: None.

OTHER:

Moderately objectionable deficiency even though I could put pipper where I wanted it.

EVALUATION NO. 137	CONFIGURATION NO. 3-4N2	PILOT: B	TASK: HUD tracking Flight Phase Cat.A
τ_R = .25	p/F_{AS} = 25	TIME DELAY: 0	COMMAND GAIN: Nonlinear 2
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No undesirable motions. Final response fine. Initial response good but puzzling. Predictability quite good. Aggressiveness didn't hurt precision/ accuracy. Rudder didn't help.

CONTROL SYSTEM FEEL:

Forces fine. Lateral sensitivity not bad - but puzzling.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Could possible be a PR=2.

HUD TRACKING:

All comments are for HUD tracking.

EVALUATION NO. 211	CONFIGURATION NO. 3-4F1N2	PILOT: B	TASK: HUD tracking Flight Phase Cat.A
τ_R =.25	p/F_{AS} =25	TIME DELAY: 0	COMMAND GAIN: Nonlinear 2

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

No PIO or ratcheting - tended to get a heading overshoot and small bobble in bank tracking. One or two overshoots during bank tracking if I was aggressive. Bank angle predictability was pretty good - overshoots/bobble wasn't too big. Aggressiveness hurt precision and accuracy.

CONTROL SYSTEM FEEL:

No complaint - maybe a bit light lateral forces.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 169	CONFIGURATION NO. 3-4T1F1N2	PILOT: B	TASK: Gun tracking
τ_R = .25	p/F_{AS} = 25	TIME DELAY: .075	COMMAND GAIN: Nonlinear 2
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Very definite PIO - started diverging once - depended on how tightly I closed the loop. Very high frequency PIO - but not ratcheting. Initial response - didn't feel like it started right away. Final response/roll rate OK. Predictability poor - very poor. Starting or stopping didn't have any idea what I would get from an input. Aggressiveness surely made accuracy worse. Very smooth non-aggressive motions were no problem. Got lots of overshoots when I started to be aggressive. Gross acquisition and fine tracking both poor - more a question of how quickly I put inputs in rather than how far I had to go. Rudder didn't help. Consciously correcting for PIO.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Forces/displacements OK. Lateral sensitivity OK initially - but then much too high.

OTHER:

Almost a PR=9

EVALUATION NO. 204	CONFIGURATION NO. 3-4T1F4D2	PILOT: P	TASK: HUD tracking Flight Phase Cat.A

τ_R = .25	p/F_{AS} = 25	TIME DELAY: .075	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.5s+1}$	REMARKS: ζ_{DR} = 0.8	SAFETY PILOT RATING 7	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Tendency to PIO if aggressive. Could do heading task if I backed off on aggressiveness with at least adequate performance. But got into PIO if aggressive. Certainly got into PIO during bank tracking. Initial response wasn't there - final response unpredictable. Definitely a function of aggressiveness/not really of size.

CONTROL SYSTEM FEEL:

Not a factor.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 185	CONFIGURATION NO. 4-2	PILOT: B	TASK: Gun tracking

τ_R =0.20	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Configuration in doubt. Not used in analysis.	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

No undesirable motions - sluggish. No PIO, certainly no ratcheting. Initial response slow, sluggish - tended to overdrive it. Final response seemed sufficient in giving enough roll rate. Took a lot of force. Predictability not too bad especially considering the heavy initial forces. Aircraft stopped nicely. Aggressiveness helped speed up response. Gross acquisition was hardest task. No problem in fine tracking. Compensation was over-driving to get it going faster.

CONTROL SYSTEM FEEL:

Lateral forces high initially and finally. Sensitivity low. Harmony did not affect rating but roll force noticeably heavy.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 12	CONFIGURATION NO. 5-2	PILOT: B	TASK: Formation and gun tracking

τ_R = .15	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Wing rocking. Roll oscillations. Quick, sharp, ratcheting. Took off pretty smartly initially, but felt heavy for final response. Predictability not very good. Quicker the input, the worse it got. Oscillations even beginning to bother gross acquisition. Certainly did bother fine tracking. Rudders didn't help. Only compensation was to back off in aggressiveness.

LATERAL POSITION CONTROL:

Could hold formation position OK - but didn't like roll oscillations.

CONTROL SYSTEM FEEL:

Felt a bit heavy in roll. Displacements OK. Felt a bit sensitive - because it took off all at once.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING: None.

OTHER:

Rating results from "deficiencies require improvement" statement in rating scale, not necessarily from performance/workload.

EVALUATION NO. 209	CONFIGURATION NO. 5-2	PILOT: B	TASK: HUD tracking Flight Phase Cat.A
τ_R = .15	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: VSS gain setting error. Not used in analysis.	SAFETY PILOT RATING 5	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

No PIO/ratcheting/overshoots. Initial response and final response terrible. High forces/sluggish acting airplane. Roll rate stopped OK - no overshoots. Predictability not too bad. Aggressiveness didn't hurt precision - but did make heavy forces more noticeable. Compensation technique - just grit your teeth and put in enough force to get response you want.

CONTROL SYSTEM FEEL:

Lateral force very high. Displacements felt high. Lateral sensitivity very low. Harmony problem. Lateral much heavier than pitch.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 3	CONFIGURATION NO. 5-2	PILOT: B	TASK: Formation and gun tracking
τ_R = .15	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Jerky, sharp, ratcheting. Quick, not large undesirable motions. Not predictable for fine tasks/tracking. Final roll rate OK. Aggressiveness hurt precision. Rudders didn't help - didn't find any compensation techniques.

LATERAL POSITION CONTROL:

Could hold formation position easily.

CONTROL SYSTEM FEEL:

Forces/displacement/sensitivity not objectionable.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

No turbulence.

EVALUATION NO. 67	CONFIGURATION NO. 5-2T1	PILOT: B	TASK: Air refueling
τ_{R}=.15	p/F_{AS} = 10	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Few sharp, short overshoots - ratcheting. The more aggressive I was the more overshoots I got. Offset maneuver resulted in several small ones. Even when I was not being aggressive - as when maintaining wings level with the tanker - if I took my mind off it for a second, wings would start to rock very quickly - short snappy response. Couldn't find a compensation technique that would stop it - just had to put up with it. Rudder didn't help.

LATERAL POSITION CONTROL:

Despite ratcheting I could still plug in - but ratcheting was very annoying and requires improvement.

CONTROL SYSTEM FEEL:

Initial lateral force very light - every time I put an input in, the plane took off. Final/steady state forces - fine. Displacements fine. Too sensitive for small inputs - too sharp.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

OTHER:

Do have adequate and perhaps "tolerable" workload - but deficiencies (ratcheting) require improvement. Hence PR=7.

HUD TRACKING:

Not done.

EVALUATION NO. 13	CONFIGURATION NO. 5-2T3	PILOT: B	TASK: Formation and gun tracking

τ_R = .15	p/F_{AS} = 10	TIME DELAY: .125	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Ratcheting. Even in a smooth turn must wait a long time for ratcheting to stop. Takes off like gangbusters initially. Jumps on you; jerky. Cannot fly smoothly at all. Final response/roll rate fine. Lacked predictability dismally. Aggressiveness made it worse definitely. Fine tracking out of the question. Gross acquisition better but still not good. Used rudder just because I hated to use aileron - started ratcheting.

CONTROL SYSTEM FEEL:

Forces light, but usable. Displacement OK. Sensitivity possibly too high because it took off so quickly and with so little force.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Bordering on PR=9. PR=8 for both formation and gun tracking.

EVALUATION NO. 116	CONFIGURATION NO. 5-2F1	PILOT: B	TASK: Gun tracking
τ_R = .15	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Small bank overshoot. No real PIO. No ratcheting. A little slow initially. Final response fine. Predictability fair - would like it a bit "tighter." Notice a delay between input and response - could definitely feel buildup of response. For small smooth changes precision and accuracy were fine. For large changes it was a bit sluggish - small overshoot. Fine tracking OK. Gross acquisition sluggish.

LATERAL FLIGHT PATH CONTROL:

Could change bank reasonably well - had some trouble moving pipper though.

CONTROL SYSTEM FEEL:

Lateral forces felt high - on the edge of too high. Lateral sensitivity a little low. Displacements - maybe overdriving laterally to get desired response.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING (Bank):

One difference between bank task and gun tracking is lack of requirement to move pipper. Do see one overshoot though.

EVALUATION NO. 77	CONFIGURATION NO. 5-2F1	PILOT: B	TASK: Air refueling

τ_R=.15	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Not really a PIO - overshoots. Predictability poor. Compensation technique really had to use rudder. Felt like I had to overdrive ailerons.

LATERAL POSITION CONTROL:

Overshooting from one side of basket to the other, especially if aggressive.

CONTROL SYSTEM FEEL:

Ailerons felt heavy - initially and finally. Felt like lateral displacement was higher. Sensitivity low - would have liked more effect for a given input. Much heavier in ailerons than in pitch.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

OTHER:

Workload tolerable if use rudders $\Rightarrow$PR=5. PR=7 if don't use rudders.

HUD TRACKING:

Not done.

EVALUATION NO. 127	CONFIGURATION NO. 5-2F2	PILOT: B	TASK: Gun tracking

τ_R = .15	P/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.17s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Small tendency to overshoot - not a PIO. Not ratcheting. Initial response a little slow - motion started right away but took a while to build up. Spongy. Final response - could get desired roll rate but forces felt a little heavy. Predictability poor because of roll rate build up. More aggressiveness hurt precision - especially for small changes. Gross acquisition OK - took a lot of force. Problem noticed during fine tracking - "loose stick." Rudders did help.

CONTROL SYSTEM FEEL:

Initial lateral forces OK but final forces heavy. Lateral displacements higher than for other configurations. Sensitivity low laterally.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 187	CONFIGURATION NO. 5-2F3	PILOT: B	TASK: Gun tracking
τ_R =0.15	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.33s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

Sluggish aircraft. Edge of PIO. Initial response - bad/sluggish. Final response - not as fast as I'd like; forces still seemed high. Predictability wallowing - poor predictability. Aggressiveness made it worse. Gross acquisition - large overshoots. Fine tracking - no good - wallowing, no nice tight feel.

CONTROL SYSTEM FEEL:

Lateral forces felt heavy. Sensitivity way too low - biggest problem with configuration.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 105	CONFIGURATION NO. 5-2T0F6	PILOT: B	TASK: Formation and gun tracking

τ_R =0.15	p/F_{AS} = 10	TIME DELAY: .055	COMMAND GAIN: Linear

PRE-FILTER: $\frac{.15s+1}{.4s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Felt a little loose/evaluation a little rushed - PR=4. Maybe would have changed rating to PR=3 if more time to evaluate. No undesirable motions. A little slow getting started. Final response fine. Predictability - expected a little more initial response than I got. Had to be pretty aggressive to get precision/accuracy, otherwise it won't have gotten over there. No overshoots - had to overdrive it a little bit; didn't feel tight. Rudder helped - but minor amount. Could do it without rudder.

CONTROL SYSTEM FEEL:

Displacement felt more because of overdriving. Sensitivity - low. Harmony OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Formation - PR=3.

EVALUATION NO. 167	CONFIGURATION NO. 5-2T1F6	PILOT: B	TASK: Gun tracking

τ_R = .15	p/F_{AS} = 10	TIME DELAY: .075	COMMAND GAIN: Linear

PRE-FILTER: $\frac{.15s+1}{.4s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

No PIO or ratcheting. Initial response and final response sluggish. Predictability degraded - felt like I was pushing a big airplane around. Aggressiveness helped. Gross acquisition was problem - just getting pipper to move - heavy airplane. Fine tracking good - once pipper was on him it stayed there. Primary compensation was overdriving stick. Rudder also helped a bit.

CONTROL SYSTEM FEEL:

Lateral forces heavy - especially for gross acquisition. Displacements seemed large - overdriving. Lateral sensitivity low. Harmony getting to be a problem.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING: None.

HUD TRACKING:

Sluggish/heavy.

EVALUATION NO. 106	CONFIGURATION NO. 5-2T1F1	PILOT: B	TASK: HUD tracking Flight Phase Cat.A
τ_R =0.15	P/F_{AS} = 10	TIME DELAY: .075	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Requires improvement/control not in question. Undesirable motion - overshoots during aggressive bank angle tracking. Initial response felt slow, sluggish, quite heavy. Final response - could get the roll rate, but sluggish even there. Not predictable - had to overdrive it and then couldn't stop it where I wanted. Precision went down with aggressiveness. Gross tracking was where overshoots were noticed. Compensation - overdrive and then guess when the best time to "back off" is.

CONTROL SYSTEM FEEL:

Forces are high - at the point where they are getting too high. Harmony bad - lighter in pitch.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 36	CONFIGURATION NO. 5-3	PILOT: G	TASK: Formation and gun tracking
τ_R =.15	ℓ/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Undesirable motions - ratcheting. Other than ratcheting - initial and final response seem pretty well coordinated. Aggressiveness hurts. Have to constantly keep your mind on being light on the stick. Had the perception that the stick was moving back and forth in my hand.

LATERLA POSITION CONTROL:

Could maintain formation position OK but had to put up with ratcheting.

CONTROL SYSTEM FEEL:

Oversensitive laterally.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

It's a PR=7 even though I could do task - ratcheting is unacceptable.

HUD TRACKING:

See ratcheting during HUD tasks as well.

EVALUATION NO. 190	CONFIGURATION NO. 5-3	PILOT: B	TASK: Gun Tracking

$\tau_R = 0.15$	$P/F_{AS} = 18$	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: *PR=7 used, rating scale anomaly Reference Eval's 12,36, 73,101,115,184,189	SAFETY PILOT RATING 4	EVAL PILOT RATING 4(7)*

ROLL ATTITUDE CONTROL:

No PIO - on the edge of ratcheting. Very jerky. Started and stopped when I asked it to. Sharp corners. Initially much too quick a response. Final response OK. Predictability poor. The more aggressive - the more annoying that deficiency became. Gross acquisition - no problem. Fine tracking was characterized by jerkiness/annoying. However, I could get desired performance

CONTROL SYSTEM FEEL:

Lateral forces light initially. Steady state no problem. Displacement - not noticed. Too sensitive.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER: *Given PR=4 but 7 used for reasons noted in remarks.

EVALUATION NO. 121	CONFIGURATION NO. 5-3	PILOT: P	TASK: Gun tracking

$\tau_R = 0.15$	$P/F_{AS} = 18$	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Aileron buzz affected evaluation. Not used in analysis.	SAFETY PILOT RATING $4\frac{1}{2}$	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Desired performance but uncomfortable, abrupt initial response...."and I'll disregard the system noise..." Attitude control good. No undesirable motions except for that initial "jump", but really not that bad. Response was predictable and not a function of aggressiveness. Tracking good for both gross acquisition and fine tracking. No compensation.

CONTROL SYSTEM FEEL:

All OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 210	CONFIGURATION NO. 5-3	PILOT: B	TASK: HUD tracking Flight Phase Cat.A
τ_R =.15	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: PR=7 used* see comments for Eval 190	SAFETY PILOT RATING 4	EVAL PILOT RATING 4(7)*

ROLL ATTITUDE CONTROL:

No PIO or ratcheting. Put an input in and here came the response. Final roll rate OK - just not predictable - couldn't tell where it was going to stop - kept accelerating on you - got more than I expected. Aggressiveness made it worse as far as being annoying, however I could stop it right where I wanted as far as precision and accuracy were concerned.

CONTROL SYSTEM FEEL:

Initial lateral force felt heavy but then response started and final roll rate/force was OK. Similarly initial sensitivity was low.

TURBULENCE/CROSSWIND EFFECT ON PIO RATING:

None.

OTHER:

PR=4 due to annoying deficiency, despite desired performance. Deficiencies almost require improvement (PR=7).* PR=7 used for analysis.

EVALUATION NO. 184	CONFIGURATION NO. 5-3	PILOT: B	TASK:HUD tracking Flight Phase Cat.A
τ_R =.15	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Not a PIO. Started and stopped so quickly - very annoying. Got a lot of input and got it all right now. Final response/roll rate was OK. Predictability good once you learned how to fly it - just take out aileron when you got bank angle you wanted - it stopped right away. Aggressiveness didn't affect precision. Gross acquisition and fine tracking OK - considering compensation technique just described.

OTHER:

PR=7 because deficiencies require improvement - extremely annoying, even though desired performance was achieved.

EVALUATION NO. 189	CONFIGURATION NO. 5-3T1	PILOT: B	TASK: Gun tracking

τ_R =0.15	p/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Undesirable motions - very noticeable ratcheting - not a PIO. Initial response very quick, jerky and abrupt for any size input. Final response - OK if input held constant. Unpredictable because of quickness. The more aggressive I was the worse it got. Gross acquisition not as affected as fine tracking.

CONTROL SYSTEM FEEL:

Lateral forces light initially then heavied up. Much too sensitive.

OTHER:

Could get adequate performance (barely) but deficiencies require improvement.

EVALUATION NO. 88	CONFIGURATION NO. 5-3T2	PILOT: G	TASK: Air refueling
τ_R =.15	P/F_{AS} = 18	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Attitude control ridiculous once gain started coming up. Undesirable motions - PIO/lots of overshoots. Initial response - too much too quick/ unpredictable. No precision at all with any level of aggressiveness.

LATERAL POSITION CONTROL:

Could get probe in basket if smooth but wasn't confident I would stay there for any length of time.

CONTROL SYSTEM FEEL:

Lateral forces light. Sensitivity too high.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 62	CONFIGURATION NO. 5-3F1	PILOT: B	TASK: Air refueling

τ_R = .15	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Some uncertainty in predictability - mildly unpleasant. No overshoots. As with all other configurations, once plugged in the task is much easier. Pilots attention transfers from basket to tanker aircraft.

LATERAL POSITION CONTROL:

Could be aggressive without real precision degradation. Compensation - had to be conscious of flying smoothly.

CONTROL SYSTEM FEEL:

A little bit too sensitive laterally.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 164	CONFIGURATION NO. S-3F1D2	PILOT: B	TASK: Gun tracking
τ_R = .15	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS: ζ_{DR} = 0.8	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No PIO or ratcheting. Predictability OK. Fine tracking and gross acquisition good.

CONTROL SYSTEM FEEL:

A little insensitive for initial lateral inputs. Forces OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 163	CONFIGURATION NO. 5-3D2	PILOT: B	TASK: Gun tracking

τ_R = .15	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Suspected VSS error, no calib. record, not used in analysis.	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

No noticeable big overshoots. Just a spongy feeling. Noticed sponginess in initial response. Final response OK. Predictability degraded a bit due to spongy feeling - moderately objectionable. Aggressiveness degraded it even more. Once I got pipper on target and could make smaller input it would stay there nicely. Noticed most problem during gross acquisition. Rudder didn't help - compensation - slow down inputs.

CONTROL SYSTEM FEEL:

Lateral forces felt a little high - not objectionable. Lateral sensitivity low initially.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 68	CONFIGURATION NO. 5-3F3	PILOT: B	TASK: Air refueling

τ_R =.15	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No overshoots.

LATERAL POSITION CONTROL:

Could be aggressive and still be precise/accurate. Rudders weren't required. Was predictable.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and crosswind effects.

HUD TRACKING:

Not done.

EVALUATION NO. 188	CONFIGURATION NO. 5-3F3	PILOT: B	TASK: Gun tracking

τ_R =0.15	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

No undesirable motions, PIO, ratcheting. Initial response reasonable. Final response - felt I had all the roll response I needed. Predictability - wasn't too bad for fine tracking with rudder Gross acquisition - it didn't always stop where I wanted it to. Gross acquisition was a problem. Rudder helped.

CONTROL SYSTEM FEEL:

Lateral forces - OK. Sensitivity - allright. Harmony - OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 76	CONFIGURATION NO. 5-3F3	PILOT: B	TASK: Air refueling

τ_R = .15	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Little overshoot (one) on side step - learned quickly how to compensate for it. Could be aggressive without serious accuracy/precision degradation. Compensation technique - learning how to control offset rollout - minimal. Quite predictable - especially when stabilized.

CONTROL SYSTEM FEEL:

Fine.

OTHER:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 87	CONFIGURATION NO. 5-3FS	PILOT: G	TASK: Air refueling
τ_R = .15	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Smooth but sluggish. Response lags stick inputs. Corrections I make require large counter corrections to stop. Overshoots. Unwilling to be aggressive - aircraft wouldn't respond to aggressive inputs. Have no idea how large a large correction is until later.

CONTROL SYSTEM FEEL:

OK for smooth slow inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 98	CONFIGURATION NO. 5-3F6	PILOT: B	TASK: Formation and Gun Tracking
τ_R=.15	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{.15s+1}{.4s+1}$	REMARKS: Aileron Buzz Affected Evaluation. Not used in analysis*	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL: No undesirable motions - no ratcheting. Initial and final response good. Was predictable. Put in an input - roll rate built up at a rate I could understand/handle. Didn't see any large problems due to increased aggressiveness. Gross acquition no sweat. Fine tracking - every once in a while pipper moved off target more than I expected. Compensation techniques - held stick lightly because of aileron buzz not because of configuration.

CONTROL SYSTEM FEEL: Fine

TURBULENCE: None.

OTHER: Aileron buzz - had to ignore to give pilot rating. Formation would get same PR=3.

HUD TRACKING: Get buzz if aggressive - but looks good.

* For subsequent evaluations with the lag/lead filter (F6), time delay was included to introduce the low pass filters of the time delay network into the roll control system. The additional filters eliminated the aileron buzz problem but unfortunately, compromised the objective of evaluating the lag/lead filters without the delay penalties associated with the time delay network. See Appendix G for details.

EVALUATION NO. 110	CONFIGURATION NO. 5-3T1F6	PILOT: P	TASK: Formation and gun tracking
τ_R =0.15	P/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{.15s+1}{.4s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Cannot tolerate the deficiencies. Undesirable motions primarily in yaw. Not too much problem in roll control except "for what I induce in yaw with roll control." Initial response felt good. Final response - good. If more aggressive - saw yaw problem more/apparent in both aggressive fine tracking and aggressive gross acquisition. It helped to use the rudder in "that" situation. Formation - not too bad; aircraft fairly smooth. Could not get adequate performance with tolerable workload, particularly for random tracking maneuver.

CONTROL SYSTEM FEEL:

Forces/displacements - OK. Sensitivity - didn't notice it.

HUD TRACKING:

Bank angle control fine - aggressiveness yielded directional oscillations.

EVALUATION NO. 126	CONFIGURATION NO. 5-3T1F6	PILOT: B	TASK: Gun tracking
τ_R =.15	P/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{.15s+1}{.4s+1}$	REMARKS: Gain setting error. Not used in analysis.	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Stick felt heavy - airplane sluggish. No undesirable motions like PIO/ ratcheting. Biggest problem was sluggish initial response. Final response/ roll rates reasonable but took high forces. Predictability not bad once I learned to fly it like a big heavy airplane - couldn't get it going as fast as I wanted to. Aggressiveness didn't hurt - but didn't help enough to get pipper on target as quickly as I wanted. Fine tracking not as much of a problem as gross acquisition - hard to get pipper on target. Rudder helped get pipper moving.

CONTROL SYSTEM FEEL:

Lateral forces too high. Sensitivity very, very low. Harmony not good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO 82	CONFIGURATION NO. 5-3T2F1	PILOT: G	TASK: Air refueling
τ_R =.15	P/F_{AS} = 18	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Not good. Lot of undesirable motions - PIO/oscillations. Over sensitive around neutral. Predictability practically zero for roll attitude.

CONTROL SYSTEM FEEL:

Forces too light laterally - displacements too small. Lateral sensitivity too high.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Minor - tanker turbulence and directional effects.

HUD TRACKING:

Not done.

EVALUATION NO. 120	CONFIGURATION NO. 5-3T1F1	PILOT: P	TASK: Gun tracking
τ_R =0.15	p/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Controllability not in question. Ratcheting, abrupt initial response. In general, gross acquisition was not a problem, but fine tracking definitely a problem. Initial response jerky - with delay. Once it got going, felt like I knew what I was going to get - reasonable. Aggressiveness amplified ratcheting. Rudder used to try to smooth things out.

CONTROL SYSTEM FEEL:

Forces - comfortable. Sensitivity - OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 168	CONFIGURATION NO. 5-3N2	PILOT: B	TASK: Gun tracking
τ_R = .15	p/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Nonlinear 2
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4½

ROLL ATTITUDE CONTROL:

Beginning of ratcheting - not strong, can feel it more than I can see it. Initial response very quick - maybe too quick. Final response/roll rate fine. Predictability was degraded - I was surprised I could get as good performance (pipper placement) and bank accuracy as I got because I was being jerked around. Jerky even with small inputs but precision was degraded with aggressiveness. Gross acquisition no problem. Backing off on task didn't really help because I got jerky response for whatever input I used.

CONTROL SYSTEM FEEL:

Lateral forces fine - maybe a little light on initial jumping. Displacements fine. Lateral sensitivity a bit too high.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

PR=4½ because deficiency was moderately objectionable - but still could get desired performance.

HUD TRACKING:

Jerky - sharp/square response. Start of ratchet - superimposed on steady roll rate, but still accurate.

EVALUATION NO. 174	CONFIGURATION NO. 5-3N3	PILOT: P	TASK: HUD tracking Flight Phase Cat.A
τ_R = .15	P/F_{AS} = 18	TIME DELAY: 0	COMMAND GAIN: Nonlinear 3
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Initial response too abrupt. Aggressiveness not a factor. No compensation. Get immediate response for small inputs - jumps, but get inadequate final roll rate for large inputs - more noticeable during heading tracking.

CONTROL SYSTEM FEEL:

Lateral force high and sensitivity low for large roll rates. Harmony a little out wack for large inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 202	CONFIGURATION NO. 5-3T1N3	PILOT: P	TASK: HUD tracking Flight Phase Cat.A
τ_R = .15	p/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Nonlinear 3
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 4½

ROLL ATTITUDE CONTROL:

Little bit of ratcheting - function of aggressiveness. Initial response comes on quite quickly. Initial and final response predictable. Aggressiveness didn't really degrade precision/accuracy, but did increase ratcheting - undesirable.

CONTROL SYSTEM FEEL:

Lateral force a bit high for steady state roll rate. Sensitivity a bit low.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 175	CONFIGURATION NO. 5-3T1N3	PILOT: P	TASK: HUD tracking Flight Phase Cat.A
τ_R = .15	p/F_{AS} = 18	TIME DELAY: .075	COMMAND GAIN: Nonlinear 3
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Predictable. Could be aggressive without degrading precision/accuracy. Felt like there was a difference between small and large inputs. Initial response was very quick - jumped out - then roll rate kind of washed out for larger inputs.

CONTROL SYSTEM FEEL:

Lateral force a bit high for larger inputs but OK. Sensitivity a bit low for larger inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 19	CONFIGURATION NO. L1-1	PILOT: P	TASK: ILS and landing
τ_R = .8	p/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial response good. Comfortable. Predictable. No degradation with aggressiveness. No real compensation required.

LATERAL FLIGHT PATH CONTROL:

Quite trimmable. No problem with heading or bank angle. High workload during ILS - probably my proficiency. No real difference small vs. large corrections.

CONTROL SYSTEM FEEL:

Forces comfortable. Displacements OK. Sensitivity felt good. Didn't require a lot of input to get what I wanted.

TURBULENCE/CROSSWIND EFFECT ON RATING:

None to minor.

HUD TRACKING:

Same pilot rating for HUD tracking as for ILS and landing.

EVALUATION NO. 192	CONFIGURATION NO. L1-1	PILOT: P	TASK: Landing

τ_R = .8	p/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

Tendency to overshoot for large aggressive inputs. Initial response sluggish/ final response inadequate. Predictability good for initial response - but final response for large inputs not predictable. More aggressiveness led to more overcontrol. Problem a function of size of inputs - just sluggish for small inputs - over response for large inputs.

LATERAL FLIGHT PATH CONTROL:

Was trimmable.

CONTROL SYSTEM FEEL:

Lateral forces heavy - affects harmony. Lateral sensitivity low.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Strong crosswind (10^{o} crab). Some turbulence - moderate effect on task.

EVALUATION NO. 141	CONFIGURATION NO. L1-2	PILOT: P	TASK: Landing
τ_R =0.8	P/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Little bit sluggish but not really a problem - minimal compensation. No undesirable motions. Predictability good. No effect of aggressiveness. No effects of size of inputs.

CONTROL SYSTEM FEEL:

Forces a shade on high side - not uncomfortable. Harmony OK.

EVALUATION NO. 4	CONFIGURATION NO. L1-2	PILOT: B	TASK: ILS and Landing
τ_R =.8	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Didn't notice any difference between initial and final response. Predictable. No rudder required.

LATERAL FLIGHT PATH CONTROL:

Was trimmable. No tendency to overshoot.

CONTROL SYSTEM FEEL:

Forces/displacement/sensitivity fine.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

No turbulence.

HUD TRACKING:

Nothing new - just as solid.

EVALUATION NO. 138	CONFIGURATION NO. L1-2	PILOT: P	TASK: Landing
τ_R =0.8	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Strange aircraft - for slightly more aggressive inputs than normally used in power approach, could get yourself in trouble - so something different for large inputs. Some but not significant undesirable motions. Initial response seemed to be there if relatively unaggressive (typical power approach). Problem with predictability for large inputs due to final response. Aggressiveness definitely had an effect - can't put a finger on it. No compensation.

LATERAL FLIGHT PATH CONTROL:

No problems with flight path or heading control.

CONTROL SYSTEM FEEL:

Forces/displacements - no problem. Sensitivity not a problem.
Harmony - OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

No turbulence.

OTHER:

Felt in the border of "something" that might be a problem when upset by gust or something that requires large amplitude aggressive corrective inputs.

HUD TRACKING:

Not done.

EVALUATION NO. 26	CONFIGURATION NO. L1-2T1	PILOT: B	TASK: ILS and landing
τ_R = .8	p/F_{AS} = 10	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial and final response fine. Predictability fine. Could be aggressive with no problem. No compensation required.

LATERAL FLIGHT PATH CONTROL:

Trimmability fine. Could control flight path accurately and precisely even for large offset correction. Instrument ILS and visual both fine.

CONTROL SYSTEM FEEL:

Forces/displacements/sensitivity/harmony all good.

TURBULENCE/CROSSWING EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Just about the same - maybe getting a slight overshoot for bank tracking task. Possibly PR=3 for bank tracking.

EVALUATION NO. 193	CONFIGURATION NO. L1-2T1	PILOT: P	TASK: Landing
τ_R = .8	p/F_{AS} = 10	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Small tendency to overshoot bank. Initial response OK. Something a bit unpredictable about final response - definitely a function of aggressiveness. Problem not too obvious with aggressiveness level used during landings.

LATERAL FLIGHT PATH CONTROL:

Was trimmable.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Strong crosswind (10^{o} crab). Some turbulence - moderate effect on rating.

HUD TRACKING (BANK):

Was more aggressive during HUD task - bank overshoot problem more obvious.

EVALUATION NO. 91	CONFIGURATION NO. L1-2T2	PILOT: P	TASK: ILS and landing
τ_R = .8	p/F_{AS} = 10	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: VSS dumped prior to touchdown. May have influenced P.R.*	SAFETY PILOT RATING 5	EVAL PILOT RATING 7

ROLL ATTITUDE CONTROL:

Got bank overshoot during aggressive side step. Initial response not there when I really demanded it so I had problems predicting final response. Definitely a function of aggressiveness - problems much more noticeable during side step than during ILS or even during touchdown. Felt an initial lag. Did not use compensation techniques.

LATERAL FLIGHT PATH CONTROL:

Not really good on ILS - maybe partly pilot HUD interpretation. Clearly most difficult subtask is visual side step.

CONTROL SYSTEM FEEL:

Lateral forces felt spongy for large inputs - forces maybe a bit high.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Can see lag during bank tracking just like during side step.

* not used in analysis

EVALUATION NO. 129	CONFIGURATION NO. L1-2T2	PILOT: P	TASK: ILS and landing
τ_R = .8	P/F_{AS} = 10	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 6	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

Start of overcontrol/PIO for large inputs or aggressive small inputs. Bit of a lag in initial response - some bother on ILS. Final response not much of a problem from roll rate standpoint, but was a problem for predictability. Effect of initial delay more noticeable as aggressiveness went up - like in offset correction.

LATERAL FLIGHT PATH CONTROL:

Problem greater during visual offset than during ILS, but had some trouble with heading during ILS.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Would give PR=4½ for ILS. PR=6 is for aggressive side step maneuver.

EVALUATION NO. 22	CONFIGURATION NO. L1-2T3	PILOT: B	TASK: ILS and landing
τ_R = .8	p/F_{AS} = 10	TIME DELAY: .125	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Overshoots - almost a PIO. Felt sluggish initially. Final response/roll rate usable. Predictability was bad. Had a hard time telling when it was going to stop when I took the inputs out. I would hate to be aggressive with this aircraft close to the ground. Problem not bad during smooth ILS - but was really bad when I started making large visual inputs. Gross maneuvers much worse than fine. Only compensation was to back off on aggressiveness.

LATERAL FLIGHT PATH CONTROL:

Trimmability OK. Precision and accuracy not bad during ILS - smaller inputs. Noticed problem much more when visual but I was being much more aggressive. Did notice some sluggishness and overshooting during ILS.

CONTROL SYSTEM FEEL:

Felt a bit heavy laterally because of sluggishness. Displacement OK. Sensitivity low. Harmony - ailerons a bit heavy but harmony OK.

HUD TRACKING:

Almost feel out of control when doing heading and bank tasks. Bank worse. Get 3 overshoots. Bank task is close to a PR=9.

EVALUATION NO. 20	CONFIGURATION NO. L1-2T4	PILOT: P	TASK: ILS and landing
τ_R = .8	p/F_{AS} = 10	TIME DELAY: .225	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Lateral PIO during visual offset correction - especially if I was aggressive for large changes. Had trouble getting what I wanted initially - made final response unpredictable - so I tended to overcontrol. PIO was a function of aggressiveness. Had trouble on ILS but things got significantly worse when I got in close and made the visual offset correction. Couldn't compensate. Wandered around in heading on ILS.

LATERAL FLIGHT PATH CONTROL:

Interestingly, I had more difficulty with my pitch control because of the effort I expended in bank control. Before offset correction visual was easier than ILS because of additional cues - but as soon as attempted a large correction have large problems.

CONTROL SYSTEM FEEL:

Nothing obviously bad about forces or displacements. Sensitivity - seemed like initially I wasn't getting enough and then it was too sensitive. Harmony OK.

TRUBULENCE/CROSSWIND EFFECT ON RATING:

Had 7-8 knots @ 90^{o}. Had to work harder at lineup, crosswind effect moderate in relation to configuration.

OTHER:

Would give ILS alone a PR=6.

HUD TRACKING:

HUD tasks are more representative of close in visual task than ILS task.

EVALUATION NO. 151	CONFIGURATION NO. L1-2F1	PILOT: P	TASK: Landing
τ_R =0.8	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

For large inputs - aircraft jumped out at me. Initial response felt like it was going to be a lot more than I got. Gave problems with final response. Initial response was a little too much. Aggressiveness hurt precision because of quick initial response. Bank angle acquisition was good, problem was initial response.

CONTROL SYSTEM FEEL:

Forces light, comfortable. Felt a little too sensitive for initial response.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Crosswind present - minor effect.

HUD TRACKING:

Not done.

EVALUATION NO. 128	CONFIGURATION NO. L1-2F1	PILOT: P	TASK: ILS and landing
τ_R =.8	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Tendency to over-bank during offset correction. Initial/final response good for small inputs - final response unpredictable for large inputs. Problem present during aggressive offset correction.

LATERAL FLIGHT PATH CONTROL:

No problem with bank/heading during ILS. Instrument ILS was easy.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING: None

OTHER:

Would give PR=2 for ILS alone. PR=5 is for offset correction.

EVALUATION NO. 140	CONFIGURATION NO. L1-2F2	PILOT: P	TASK: Landing

τ_R =0.8	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.17s+1}$	REMARKS: First side-step more aggressive than others.	SAFETY PILOT RATING 8	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Definite tendency to PIO. Didn't get into it because I backed off on task to prevent it. Initial allright then it really came on. Predictability lousy. Aggressiveness really hurt aircraft - backed off from it for control.

LATERAL FLIGHT PATH CONTROL:

Bank angle problems. Large inputs probably worse. Unaggressiveness inputs not as bad as for large.

EVALUATION NO. 150	CONFIGURATION NO. L1-2T1F1	PILOT: P	TASK: Landing
τ_R =0.8	P/F_{AS} = 10	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 6

ROLL ATTITUDE CONTROL:

Tendency to overshoot - for small inputs. For large inputs, aircraft felt like it was going to take off. Initial response seemed to be delayed, final response seemed to speed up. Tendency to over-bank. Poor predictability. Toned down side step because knew I could get into trouble. Large inputs could get into trouble. Small inputs not too bad; reasonably controllable.

CONTROL SYSTEM FEEL:

Forces - not noticeable. Sensitivity not a factor.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Crosswind present - minor effect.

HUD TRACKING:

Not done.

EVALUATION NO. 5	CONFIGURATION NO. L2-1	PILOT: B	TASK: ILS and VFR landing
τ_R = .45	P/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial and final response OK. Predictable. Used rudders some (perhaps a bit of compensation).

LATERAL FLIGHT PATH CONTROL:

Track was no problem. Having some trouble getting used to HUD.

CONTROL SYSTEM FEEL:

Forces/displacements/sensitivity OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 152	CONFIGURATION NO. L2-1T1	PILOT: P	TASK: Landing
τ_R =0.45	P/F_{AS} = 5	TIME DELAY: .075	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial/final responses predictable but a little less than desired. A little unresponsive/heavy forces. Predictably OK. Aggressiveness didn't have a lot of bearing on it. Small vs. large inputs not a factor except large inputs required large force levels.

CONTROL SYSTEM FEEL:

Lateral forces high. Lateral sensitivity low. Harmony - lateral forces heavier.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Crosswind present - minor effect.

HUD TRACKING:

Not done.

EVALUATION NO. 139	CONFIGURATION NO. L2-1T2	PILOT: P	TASK: Landing
τ_R =0.45	P/F_{AS} = 5	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Don't like configuration. Tendency to over-bank/overshoot. Initial response was sluggish then got too much. Some predictability problems with final response. A function of aggressiveness - problems: initial delay/ inadequate response. Tendency of attitude/rate to rush up on me.

LATERAL POSITION CONTROL:

Heading not difficult. Bank angle was a problem.

CONTROL SYSTEM FEEL:

Forces are spongy/a little heavy initially. Problem with sensitivity similar to forces/hard to differentiate.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Turbulence not a factor.

HUD TRACKING:

Not done.

EVALUATION NO. 27	CONFIGURATION NO. L2-1T4	PILOT: B	TASK: ILS and landing
τ_R=0.45	p/F_{AS} = 5	TIME DELAY: .225	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 8	EVAL PILOT RATING 9

ROLL ATTITUDE CONTROL:

Large lower frequency oscillations - not ratcheting - was PIO. Initial response felt sluggish - final response not bad. Had to almost overdrive it to get the initial roll rate I wanted. Predictability was atrocious. Tried flying smoothly - that didn't work - so I tried being aggressive and if anything that made it worse. Wasn't aware of any compensation techniques - just tried to stay ahead of the aircraft.

LATERAL FLIGHT PATH CONTROL:

Trimmability OK. Oscillation in bank and heading - never got track right. While flying smoothly on instruments I only noticed a small sluggishness. But once visual and had to offset it really went to pieces. Large changes triggered the whole thing.

CONTROL SYSTEM FEEL:

Lateral forces felt high - considerably higher than I would like them. Displacement OK. Sensitivity terrible - very insensitive - sluggish a better word. Definitely lighter in pitch.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Can see problem. Not as concerned with losing control though. Can definitely feel same thing I felt during visual. If very aggressive, get definite PIO.

EVALUATION NO. 23	CONFIGURATION NO. L2-1F1	PILOT: B	TASK: ILS and landing
ζ_R =0.45	p/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Only a very slight tendency to overshoot. Initial response a bit slow. Final response sufficient. Predictability was fine. Could be aggressive without loss of precision. Very little compensation required.

LATERAL FLIGHT PATH CONTROL:

No trimmability problems. Good precision. Didn't notice too much difference between ILS and visual.

CONTROL SYSTEM FEEL:

Stick felt a little heavy for large bank changes - not uncomfortable. Sensitivity maybe a bit low but well within reason. Displacement OK.

HUD TRACKING:

Similar results.

EVALUATION NO. 194	CONFIGURATION NO. L2-1F3	PILOT: P	TASK: Landing
τ_R =0.45	p/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial and final response OK. Predictable. Precision/accuracy not really a function of aggressiveness.

LATERAL FLIGHT PATH CONTROL:

Could get bank angles and headings I wanted.

CONTROL SYSTEM FEEL:

Lateral forces a little high.

EVALUATION NO. 142	CONFIGURATION NO. L2-1F3	PILOT: P	TASK: Landing
τ_R =0.45	p/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Desired performance attainable. Tendency to over-bank/overcontrol. Initially a little sluggish then too much input used. Predictability problems for large maneuvers resulted. Precision/accuracy was a function of aggressiveness. Soft initial response. Worse for large amplitude maneuvers.

CONTROL SYSTEM FEEL:

Forces felt a little higher for initial response. Sensitivity not a problem in itself.

EVALUATION NO. 28	CONFIGURATION NO. L2-2	PILOT: B	TASK: ILS and landing
τ_R =0.45	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial and final response was fine. Very predictable. Could be very aggressive with no problem. Fine and gross maneuvering both good.

LATERAL FLIGHT PATH CONTROL:

Trimmability fine. Could control heading/bank/track precisely and accurately. No difference instruments vs. visual or large vs. small changes.

CONTROL SYSTEM FEEL:

Forces/displacements/sensitivity/harmony all good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Bank angle tracking excellent (maybe PR=1).

EVALUATION NO. 153	CONFIGURATION NO. L2-2	PILOT: P	TASK: Landing
τ_R =0.45	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Predictable. Aggressiveness not a factor. Good aircraft.

CONTROL SYSTEM FEEL:

Lateral forces comfortable. Lateral displacements/harmony OK. Sensitivity good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Crosswind present - minor factor.

HUD TRACKING:

Not done.

EVALUATION NO. 143	CONFIGURATION NO. L2-2F1	PILOT: P	TASK: Landing
τ_R =0.45	P/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Good predictability. Precision not a function of aggressiveness. Initial response nice and crisp. Final response pretty predictable. Got what I wanted as quick as I wanted it.

CONTROL SYSTEM FEEL:

Forces comfortable. Displacements/harmony/sensitivity - all OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

No factor.

EVALUATION NO. 195	CONFIGURATION NO. L2-ℓF2	PILOT: P	TASK: Landing
τ_R =0.45 p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear	
PRE-FILTER: $\frac{1}{.17s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Small tendency to overshoot if aggressive. Little bit of predictability problem. Could be precise/accurate with normal aggressive levels.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Strong crosswind (10^{o} crab). Some turbulence. Moderate effect on task.

EVALUATION NO. 24	CONFIGURATION NO. L2-2F3	PILOT: B	TASK: ILS and landing
τ_R=0.45	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.3s+1}$	REMARKS:	SAFETY PILOT RATING 7	EVAL PILOT RATING 8

ROLL ATTITUDE CONTROL:

Roll oscillations - felt like I was inducing them but I couldn't stop. Initial and final response OK. Predictability not good for small inputs. Better for large inputs. Could do large aggressive corrections OK - biggest problem was trying to make small fine visual corrections. Always ended up with unwanted roll oscillations. No compensation techniques worked other than just trying hard.

LATERAL FLIGHT PATH CONTROL:

Trimmability OK. Had problem with bank angle - not really with heading/ track. Didn't have as much problem when on instruments - noticed it when visual - trying to make small visual corrections in the flare.

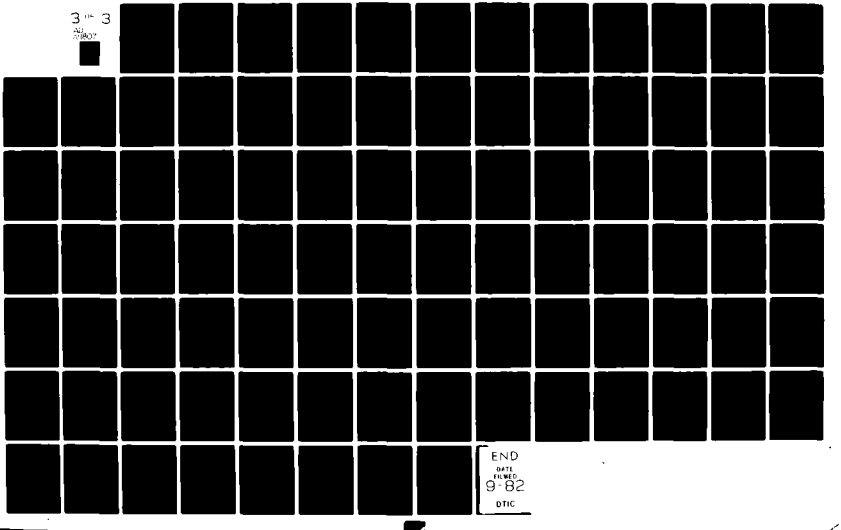
CONTROL SYSTEM FEEL:

Forces and displacements OK. Sensitivity not bad. Got the roll rate I wanted for a given input. Harmony OK.

HUD TRACKING:

See same overshoots during heading tracking and during bank tracking.

AD-A118 071 CALSPAN CORP BUFFALO NY FLIGHT RESEARCH DEPT F/G 1/3
LATERAL FLYING QUALITIES OF HIGHLY AUGMENTED FIGHTER AIRCRAFT, --ETC(U)
MAR 82 S J MONAGAN, R E SMITH, R E BAILEY F33615-79-C-3618
UNCLASSIFIED CALSPAN-6645-F-8-VOL-2 AFWAL-TR-81-3171-VOL-2 NL



EVALUATION NO. 144	CONFIGURATION NO. L2-2D1	PILOT: P	TASK: Landing

τ_R =0.45	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: ζ_{DR} = 0.6	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial and final response both predictable. Aggressiveness not a factor. Precision was good - got what I wanted and not a function of size of inputs.

CONTROL SYSTEM FEEL:

Forces - comfortable. All the rest - OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

No factor.

EVALUATION NO. 196	CONFIGURATION NO. L2-2D1	PILOT: P	TASK: Landing

τ_R =0.45	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: ζ_{DR} =0.6	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

Liked it. Predictable. Could be aggressive and still be precise/adequate.

CONTROL SYSTEM FEEL:

Good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Strong crosswind (10° crab). Moderate turbulence/gusts. Moderate effect on task.

EVALUATION NO. 92	CONFIGURATION NO. L3-1	PILOT: P	TASK: ILS and landing
τ_R = .25	P/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

Pretty good attitude control. Bank angle response not crisp but comfortable - most noticeable during visual offset task - an annoyance.

LATERAL FLIGHT PATH CONTROL:

Reasonable precision/accuracy. Visual task more demanding than ILS.

CONTROL SYSTEM FEEL:

A bit of sponginess in lateral stick especially for large changes. Lateral forces a bit high. Sensitivity good for small inputs, not so good for large inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Would give same PR for bank tracking.

EVALUATION NO. 130	CONFIGURATION NO. L3-1	PILOT: P	TASK: ILS and landing
τ_R = .25	p/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Attitude control good. Initial/final response good. Predictability good - not a function of aggressiveness. Comfortable.

LATERAL FLIGHT PATH CONTROL:

Instrument and visual easy.

CONTROL SYSTEM FEEL:

Lateral forces a little heavy. Lateral sensitivity a little low.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

EVALUATION NO. 154	CONFIGURATION NO. L3-1N2	PILOT: P	TASK: Landing

τ_R=0.25	P/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Nonlinear 2

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

High stick forces. Initial response is there; comes on but then not quite enough. Predictability OK. Aggressiveness not a factor.

CONTROL SYSTEM FEEL:

Lateral forces high. Lateral sensitivity a little low. Harmony - not noticeably bad.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Crosswind present - minor effect on rating - makes a good evaluation task.

HUD TRACKING:

Not done.

EVALUATION NO. 155	CONFIGURATION NO. L3-1D1	PILOT: P	TASK: Landing

τ_R =0.25	p/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Rudder gain increased to ease cross-wind compensation by pilot. ζ_{DR} = 0.6	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Predictable. Aggressiveness or large inputs not a problem.

CONTROL SYSTEM FEEL:

For this crosswind and configuration, rudder forces were excessive - although not a serious problem. After rudder gain changed - rudder forces OK. Other forces/displacements OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Crosswind present - minor effect.

HUD TRACKING:

Not done.

EVALUATION NO. 176	CONFIGURATION NO. L3-1D1	PILOT: P	TASK: Landing

τ_R =.25	p/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: ζ_{DR} = 0.6	SAFETY PILOT RATING 3	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

No undesirable motions. Was predictable. No compensation.

LATERAL FLIGHT PATH CONTROL:

Could get what I wanted - bank/heading.

CONTROL SYSTEM FEEL:

Lateral forces high/sensitivity low for large inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING: (Bank)

See same problem.

EVALUATION NO. 6	CONFIGURATION NO. L3-2	PILOT: B	TASK: ILS and VFR landing

τ_R = .25	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

No undesirable motions. Predictable. Aggressive flying no problem.

LATERAL FLIGHT PATH CONTROL:

Well within desired limits. No velocity control problem. No problems on instruments of when visual. Small and large corrections not difficult.

CONTROL SYSTEM FEEL:

Forces/displacements/sensitivity fine.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

OTHER:

Subtasks all rated equally good.

EVALUATION NO. 214	CONFIGURATION NO. L3-2	PILOT: B	TASK: Landing

τ_R = .25	p/F_{AS} = 10	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Suspect wrong config set, no calib data, not included in analysis.	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Small roll oscillation during sidesteps - not ratcheting. Initial response a little slow. Final response/roll rate adequate - not a real responsive airplane. Predictability not too bad. Suspect aggressiveness would hurt precision.

CONTROL SYSTEM FEEL:

Lateral force a bit high but alright. Sensitivity low for small initial inputs.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Strong crosswind - moderate effect on task.

EVALUATION NO. 93	CONFIGURATION NO. L3-2T2	PILOT: P	TASK: ILS and landing
τ_R =.25	P/F_{AS} = 10	TIME DELAY: .105	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: Partial evaluation only due to VSS dumps.	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Felt some initial lag in roll response during start of side step, prior to dump - possible predictability problem. Did not notice problem during full stop landing from ILS (no offset/side step maneuver).

LATERAL FLIGHT PATH CONTROL:

Good ILS without any problem.

CONTROL SYSTEM FEEL:

Didn't notice any problem.

OTHER:

VSS dumped during offset maneuvers - could not complete them.
Performed one ILS approach to full stop landing.

HUD TRACKING:

Not done.

EVALUATION NO. 21	CONFIGURATION NO. L4-1	PILOT: P	TASK: ILS and landing
$\tau_R = .2$	$p/F_{AS} = 5$	TIME DELAY: 0	COMMAND GAIN: Linear
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 4½

ROLL ATTITUDE CONTROL:

Some undesirable motions on ILS - overcontrolling. Little bit of predictability problem, maybe a little delay. Surprisingly - seemed to have more problem on ILS than visual. Aggressiveness hurt. No real compensation.

LATERAL FLIGHT PATH CONTROL:

Not too bad. Could control pitch well. Had some heading control (chasing) on ILS.

CONTROL SYSTEM FEEL:

Lateral forces seemed high. Displacements OK. Sensitivity not too bad.

TURBULENCE/CROSSWIND EFFECT ON RATING:

Minor effects due to crosswind.

HUD TRACKING:

Noticed some Dutch roll during HUD heading tracking.

EVALUATION NO. 25	CONFIGURATION NO. L 4-1	PILOT: B	TASK: ILS and landing
τ_R = .2	P/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 5	EVAL PILOT RATING 5

ROLL ATTITUDE CONTROL:

Beginning of ratcheting - could feel a "stepping" action. Initial and final responses OK. Didn't like predictability. Every time I put an input in I felt that "stepping" - more so if I was aggressive. Noticed "stepping" more during gross maneuvers. Rudder didn't help.

LATERAL FLIGHT PATH CONTROL:

Trimmability no problem. Maybe a small bank angle control problem. Think I felt the ratcheting more during ILS than when visual. Problem was large changes more than smaller ones.

CONTROL SYSTEM FEEL:

Forces/displacements/sensitivity/harmony OK.

TURBULENCE/CROSSWIND EFFECT ON RATING:

None.

HUD TRACKING:

Saw ratcheting during bank tracking.

EVALUATION NO. 156	CONFIGURATION NO. L4-1T2	PILOT: P	TASK: Landing

τ_R =0.20	P/F_{AS} = 5	TIME DELAY: .105	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

Didn't like something, not sure what though. No undesirable motions - slight tendency to overbank. Final response - a little lack of predictability. Hard to tell but might be a function of aggressiveness. It is a function of input size.

CONTROL SYSTEM FEEL:

OK.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Crosswind present - no effect on rating.

EVALUATION NO. 206	CONFIGURATION NO. L4-1T2	PILOT: P	TASK: Landing

τ_R =.2	p/F_{AS} = 5	TIME DELAY: .105	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 3	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No undesirable motions. Predictable. Aggressiveness not a factor. Little lack of roll performance.

CONTROL SYSTEM FEEL:

Lateral force a little high especially for larger roll rates. Lateral sensitivity a little low.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Not really a factor - wind strong but down runway.

EVALUATION NO. 131	CONFIGURATION NO. L4-1F1	PILOT: P	TASK: ILS and landing
τ_R = .2	P/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Linear

PRE-FILTER: $\frac{1}{.1s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 3

ROLL ATTITUDE CONTROL:

No undesirable motions. Predictable - aggressiveness no factor. A little sluggish in roll - didn't interfere.

LATERAL FLIGHT PATH CONTROL:

Instrument and visual tasks similar.

CONTROL SYSTEM FEEL:

Lateral force a little heavy, lateral sensitivity a little low.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Bank angle tracking similar to offset side step.

EVALUATION NO. 29	CONFIGURATION NO. L4-1N1	PILOT: B	TASK: ILS and landing
τ_R = .2	P/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Nonlinear 1
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 4	EVAL PILOT RATING 4

ROLL ATTITUDE CONTROL:

No undesirable motions. Initial response a little bit sluggish. But I finally got the roll rate I wanted. Noticed this during visual offset. Predictability not particularly good during offset correction, although I ended up where I wanted to be. Had to be aggressive to get where I wanted. Noticed sluggishness most during gross maneuvers rather than during fine maneuvers. Maybe used a little bit of rudder during fine maneuvering to get desired performance.

LATERAL FLIGHT PATH CONTROL:

Trimmability OK. Bank angle sluggishness affected heading and track control for large changes. Not bad for small changes.

CONTROL SYSTEM FEEL:

Lateral forces a little heavier than I would like. Displacement OK. Sensitivity for the initial response was down a bit. Harmony not a problem.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

None.

HUD TRACKING:

Can see sluggishness during bank tracking. Maybe see some small oscillations in bank.

EVALUATION NO. 197	CONFIGURATION NO. L4-1N2*	PILOT: P	TASK: Landing
$\tau_R = .2$	$p/F_{AS} = 7$	TIME DELAY: 0	COMMAND GAIN: Nonlinear 2
PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS: *NOTE: p_{ss}=7 deg/sec/lb, Special Configuration	SAFETY PILOT RATING 2	EVAL PILOT RATING 2

ROLL ATTITUDE CONTROL:

Liked it. No undesirable motions. Predictable. Could be aggressive and still be precise/accurate.

CONTROL SYSTEM FEEL:

Good.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Wind down the runway at 25 knots. Turbulent/gusty. Moderate effect on task.

EVALUATION NO. 145	CONFIGURATION NO. L4-1N4	PILOT: P	TASK: Landing

τ_R =0.2	P/F_{AS} = 5	TIME DELAY: 0	COMMAND GAIN: Nonlinear 4

PRE-FILTER: $\frac{1}{.025s+1}$	REMARKS:	SAFETY PILOT RATING 2	EVAL PILOT RATING 4½

ROLL ATTITUDE CONTROL:

Adequate but worked too hard. No undesirable motions. Predictability a problem - not enough response to inputs. Aggressiveness was a factor - could not get a response if you had to. Large inputs were difficult because of lack of performance.

CONTROL SYSTEM FEEL:

Forces quite high. Displacements not noticeable Sensitivity low/out of harmony - out of wack.

TURBULENCE/CROSSWIND EFFECT ON PILOT RATING:

Turbulence not a factor.

APPENDIX D

EVALUATION TASK DETAILS

The purpose of this appendix is to summarize the important task details as presented to the evaluation pilots. Summaries are presented for each task and the performance standards used as a guideline by the evaluation pilots are given in Table D-1 for each task.

Except for the approach and landing task and the air refueling task, the nominal conditions were:

10,000 ft MSL (±3,000 ft)

280 KIAS (550 fps TAS) ± 10%

Use of the rudder in performing the tasks was allowed, if necessary, or if rudder significantly improved task performance or reduced pilot compensation. Otherwise, use of the rudder was discouraged. The majority of the tasks emphasized precise control techniques with the exception of the gross acquisition phase of the tracking tasks. Scrutiny of the data from these evaluations indicates that the NT-33A roll rate limitation of approximately 100 deg/sec was not a significant factor in the accomplishment of these tasks.

The evaluation task descriptions given to the evaluation pilots were:

1) Flight Phase Category A Tasks:

- Close Formation Flying (TR)

Task starts with NT-33A at target's 5 o'clock or 7 o'clock position with 50 ft spacing. If flying qualities allow, evaluation pilot moves in to a close formation position at 5 or 7 o'clock but maintains nose tail spacing. Evaluation pilot directs target to begin maneuver. Target aircraft flies straight and level for one minute, then a 30° bank, 180° right turn, and finally, a 60° bank 180° left turn. Evaluation pilot maintains close formation position.

After the initial evaluation flights, it became obvious that this task was not the critical flying qualities determinant. Accordingly, this task was eliminated from the evaluation sequence in the interest of project efficiency. Evaluations with the formation task are noted in the evaluation sequence summary (Appendix B) and the pilot comment summaries (Appendix C). All tasks which include tracking and/or formation flying are designated "TR".

- Air-to-Air Gun Tracking (TR)

The air-to-air gun tracking task includes gross acquisition of an initial tracking solution and fine tracking of predictable and unpredictable targets.

- Fine Tracking Predictable Target

NT-33A establishes a 200 ft co-speed trail position on the target aircraft. Target maintains straight and level for one minute, then a 2g level 180° turn, followed by a return to straight and level. Evaluation pilot attempts to track a designated aim point on the target aircraft within ±5 mils with the HUD aiming symbol. Aiming symbol is 10 mils in diameter and intersection of "tail" and circle was the aim point.

- Gross Acquisition

After 30 seconds of straight and level flight the target begins a 2g level 180° turn. The evaluation pilot maintains wings level during the initial part of this target turn. As the target passes the NT-33A canopy bow (approximately 30° angle-off) the evaluation pilot initiates a maneuver to acquire a fine tracking solution.

- Fine Tracking Unpredictable Target

At the completion of the 180° acquisition turn the target maneuvers at approximately 280 KIAS in an unpredictable manner observing the following limits:

+3 to +½g normal acceleration

250 KIAS minimum

350 KIAS maximum

±120° bank angle

±20° pitch angle

The evaluation pilot attempts to fine track the target.

Initially the target pilots maneuvered too aggressively for realistic evaluation of the tracking capability. Holding unannounced changes for 5-8 seconds before the next change made the task reasonable.

- Air-to-Air Refueling (AR)

NT-33A establishes pre-contact position 50 ft in trail of tanker aircraft and 20 ft displaced laterally. If flying qualities allow, evaluation pilot closes to engage refueling probe in the drogue, maintaining nose tail spacing. Evaluation pilot maintains contact position for 30 seconds then disconnects and returns to pre-contact position. Repeat for a total of three contacts. Second and third contact maintained for 15 seconds.

Tanker speeds were 250 KIAS for the C-130 and 280 KIAS for the A-3 at 10,000 ft MSL ± 3000 ft. This deviation from the nominal airspeed of 280 KIAS was considered to be within the allowable airspeed deviations for the experiment despite some variations in simulated longitudinal and lateral aircraft characteristics. Calibration data indicated that the primary experiment variables remained within nominal limits.

- Bank Angle Tracking (HUD)

A command bank angle line (see Figure D-1) is programmed to appear on the DEFT HUD (see Appendix J for details) at a certain angle with respect to the horizon line (the command bank angle). While maintaining constant altitude, the evaluation pilot attempts to achieve and track the command bank angle by aligning the "wings" of the Flight Path Marker (FPM) with the command bank angle line. (FPM "wings" extended to increase resolution.) Command bank angle is changed at intervals (step, ramp, and/or continuous changes) over a period of up to 2 minutes. Programs were loaded in the DEFT computer prior to flight and initiated by safety pilot. A short HUD tracking task ($\sim$ 30 sec) was performed after most evaluations with target aircraft; for HUD-only evaluations the full tracking task was used for the evaluation. Examples of the bank angle tracking task are given in Appendix E. Maximum bank angle commands were 60° for Category A tasks and 30° for Category C tasks.

- Heading Tracking (HUD)

A heading target is displayed on the DEFT HUD (see Figure VI-2). Evaluation pilot attempts to track the command heading. Heading error is shown as a lateral displacement of the target with respect to the FPM. When the aircraft is on command heading the target is centered on the FPM. Command heading is changed at intervals (step, ramp, and/or continuous changes). Short and long programs initiated by safety pilot were used as discussed under bank angle tracking. Maximum commanded heading change was 30 deg for Category A tasks and 15 deg for Category C tasks. This task was eliminated after it was shown not to be a discriminating flying qualities task for this program.

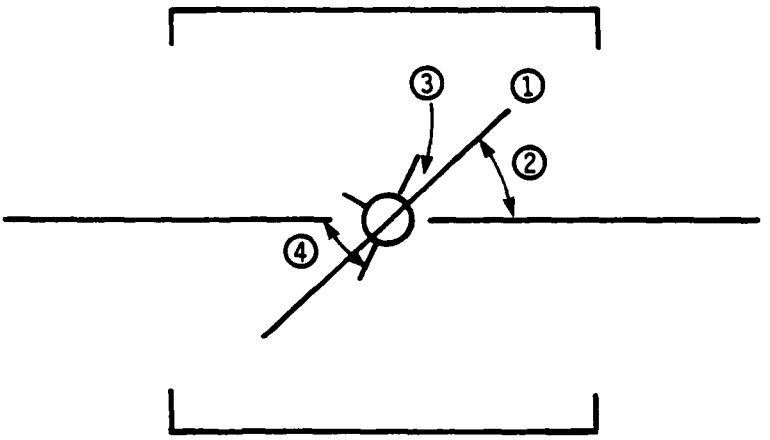
2) Flight Phase Category C Tasks:

- Instrument Landing System Approach and Visual Landing (LA)

The evaluation pilot flies an ILS approach, beginning prior to glide path interception ($\approx$ 1800 ft AGL). The HUD is the primary instrument reference and a blue/amber vision restriction system creates simulated instrument meteorological conditions (IMC). At decision height (200 ft AGL) the evaluation pilot transitions to visual meteorological conditions (VMC) by raising the blue visor. He performs a touch and go landing or, if aircraft gross weight limitations prohibit landing, a 10 ft AGL low approach. The evaluation pilot uses a side step maneuver to eliminate the line up error during the visual flare and touchdown portion of the ILS approach.

- Visual Landing (LA)

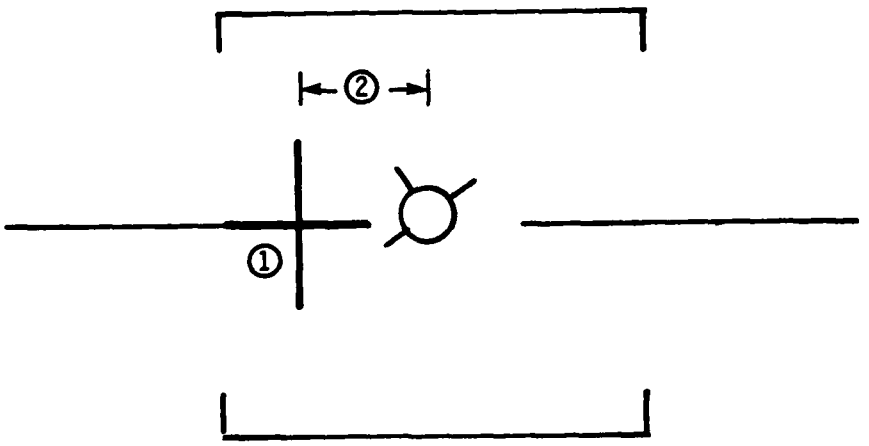
Evaluation pilot flies visual closed patterns for second landing. A 150 ft lateral offset is established on final approach. At 200 ft AGL ($\approx$ 1/2 nm) evaluation pilot performs a side step maneuver to eliminate the line-up error. A third landing was permitted if required for evaluation purposes.



1. Command Bank Angle Line
2. Command Bank Angle (ϕ_c)
3. Bank Angle Error $(\phi_e = \phi_c - \phi)$
4. Bank Angle (ϕ)

NOTE: Some symbology has been omitted for clarity. Full display is shown in Figure J-1

Figure D-1: BANK ANGLE TRACKING HUD FORMAT



1. Heading target showing command heading. (Cross always on horizon line)
2. Heading error. (Heading target centered on flight path marker when heading error is zero).

NOTE: Some symbology has been omitted for clarity.

Figure D-2: HEADING TRACKING HUD FORMAT

Since the ILS portion of the task did not prove to be a discriminating task, it was eliminated from the later evaluations. In this case, two visual-only approaches were performed; the first being a straight-in approach to landing with a small lateral offset ($\sim$ 75 ft) and the second with a larger lateral offset ($\sim$ 150 ft) following a closed VFR pattern. A third landing was again permitted if required.

NT-33A approach speeds are based on a constant angle of attack according to fuel weight; speeds ranged from 125 KIAS to 140 KIAS for the approach and landing evaluations. At nominal weight, the approach speed is 135 KIAS and touchdown speed is approximately 120 KIAS. More details on the effects of this speed profile are found in Reference 8 and Appendix G.

TABLE D-1

EVALUATION TASK PERFORMANCE STANDARD

Evaluation Task	Desired Performance Standards	Adequate Performance Standards
Close Formation Flying	No PIO Position maintained within ± 3 ft 90% of task, within ± 10 ft remainder of task.	Position maintained within ± 5 ft 50% of task, within ± 10 ft remainder of task.
Air-to-Air Tracking Gross Aquisition	Aggressively acquire aim point within 25 mils of pipper with no overshoot.	Aggressively acquire aim point within 25 mils of the pipper with no more than one overshoot.
Fine Tracking	No PIO Pipper within ± 5 mils of aim point 50% of task, within ± 25 mils remainder of task.	Pipper within ± 5 mils of aim point 10% of task, within ± 25 mils remainder of task. Would fire gun.
Air-to-Air Refueling	No PIO Contact on first attempt.	Contact after multiple attempts.
	Refueling position maintained within ± 3 ft.	Refueling position maintained within ± 5 ft.
Bank Angle Tracking	No PIO Command bank angle maintained within ± 2° 90% of task, (except for bank angle errors immediately following step command bank angle changes).	Command bank angle maintained within ± 2° 50% of task, (except for errors immediately following step changes).
Heading Tracking	No PIO Command heading maintained within ± 1° 75% of task, within ± 3° for remainder of task (except for errors immediately following step heading changes).	Command heading maintained within ± 1° 25% of task, within ± 5° remainder of task (except for errors immediately following step changes).

TABLE D-1 (concluded)

EVALUATION TASK PERFORMANCE STANDARDS

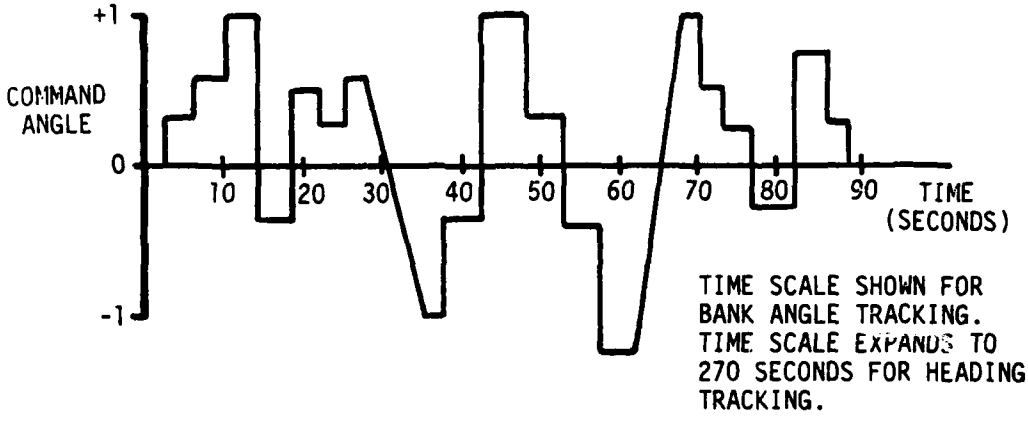
Evaluation Task	Desired Performance Standards	Adequate Performance Standards
ILS Approach	No PIO Glide slope and localizer errors less than 1/3 degree 50% of task, less than 2/3 degree remainder of task.	Errors less than 1° for task.
Visual Landing	No PIO Touchdown within 5 ft of center line and within 250 ft of aim point.	Touchdown within 20 ft of center line and within 500 ft of aim point.

APPENDIX E

TASK PERFORMANCE RECORDS

Included in this appendix are selected flight records of the HUD displayed, bank attitude tracking task (Figure E-2 through Figure E-16). These records were taken following evaluations using target aircraft in Flight Phase Category A. Only bank attitude tracking task records are presented since they more closely resemble the air-to-air gun tracking task and, therefore, provide representative compensatory tracking task performance records.

In each figure, the time histories are from top to bottom: HUD-displayed, command bank angle (ϕ_c, *degrees*), bank angle error ($\phi_e = \phi_c - \phi$, *degrees*), lateral stick force (*lbs*), and aircraft roll rate (*deg/sec*). The time axis (*in seconds*) begins at zero when the digital flight recorder starts. This may not necessarily be at the same point for each record. Table F-3 lists the start and stop time of the programmed tracking task for each configuration which can be used to derive the portion of the task from which these records were taken. The programmed HUD tracking task is shown in Figure E-1 (refer to Appendix D for details of the HUD tracking tasks).



1.0 COMMAND ANGLE = 60°, BANK ANGLE TRACKING, LANDING GEAR UP
30°, BANK ANGLE TRACKING, LANDING GEAR DOWN
30°, HEADING TRACKING, LANDING GEAR UP
15°, HEADING TRACKING, LANDING GEAR DOWN

Figure E-1: COMMAND ANGLE VS. TIME

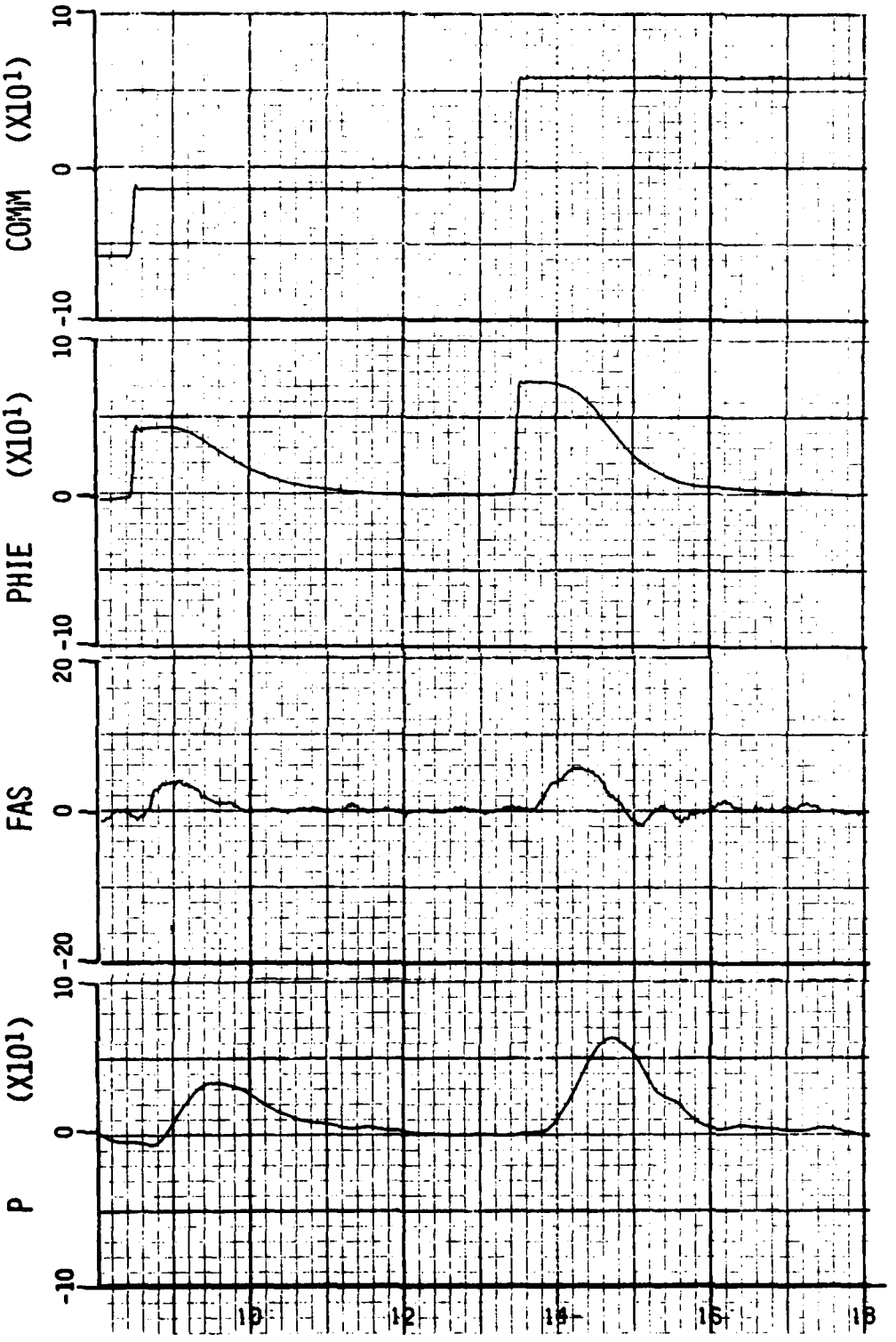


Figure E-2: BANK ANGLE TRACKING TASK (HUD) [PR = 3]
CONFIGURATION: 1-3, EVALUATION NO. 41

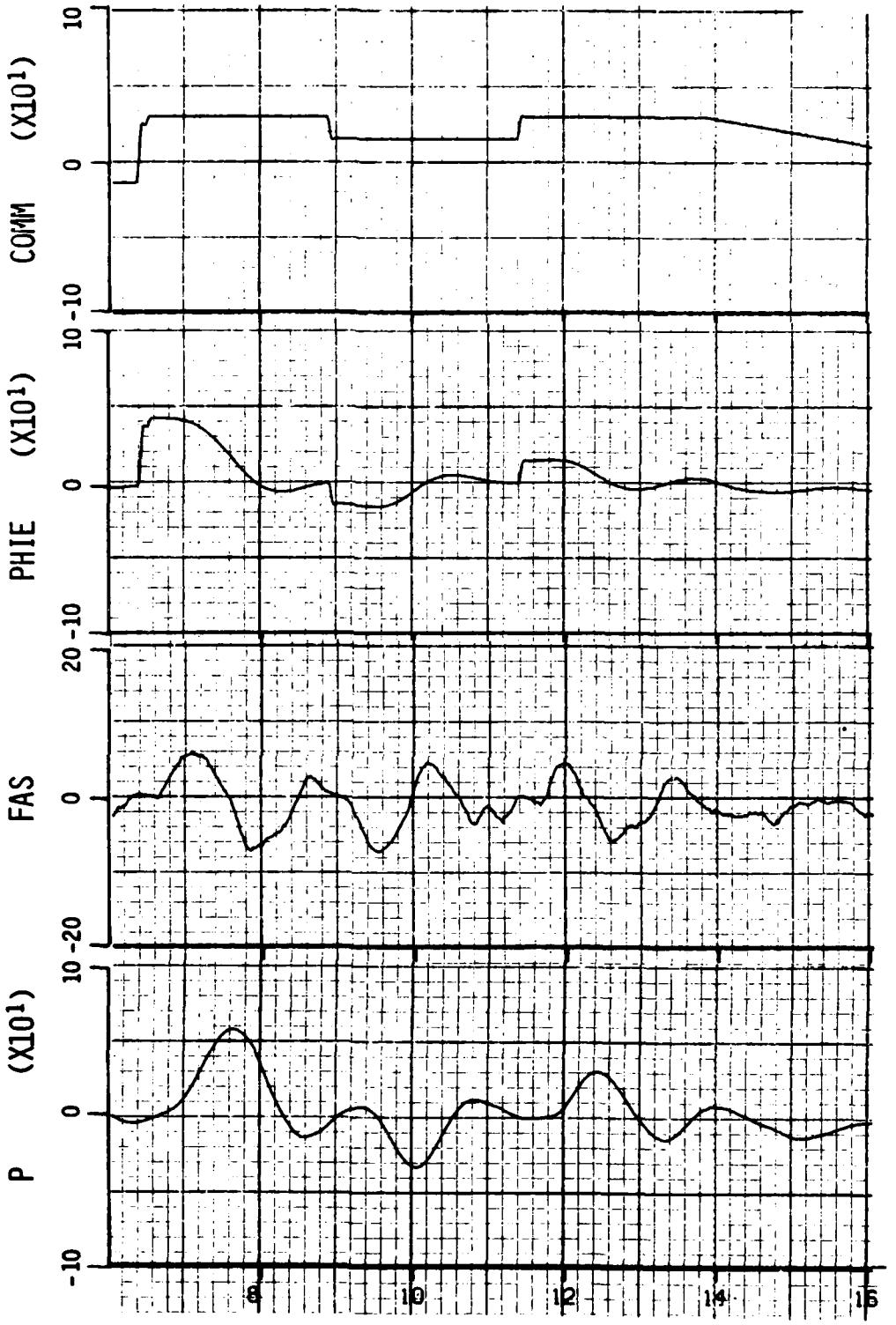


Figure E-3: BANK ANGLE TRACKING TASK (HUD) [PR = 6]
CONFIGURATION: 1-3F2, EVALUATION NO. 122

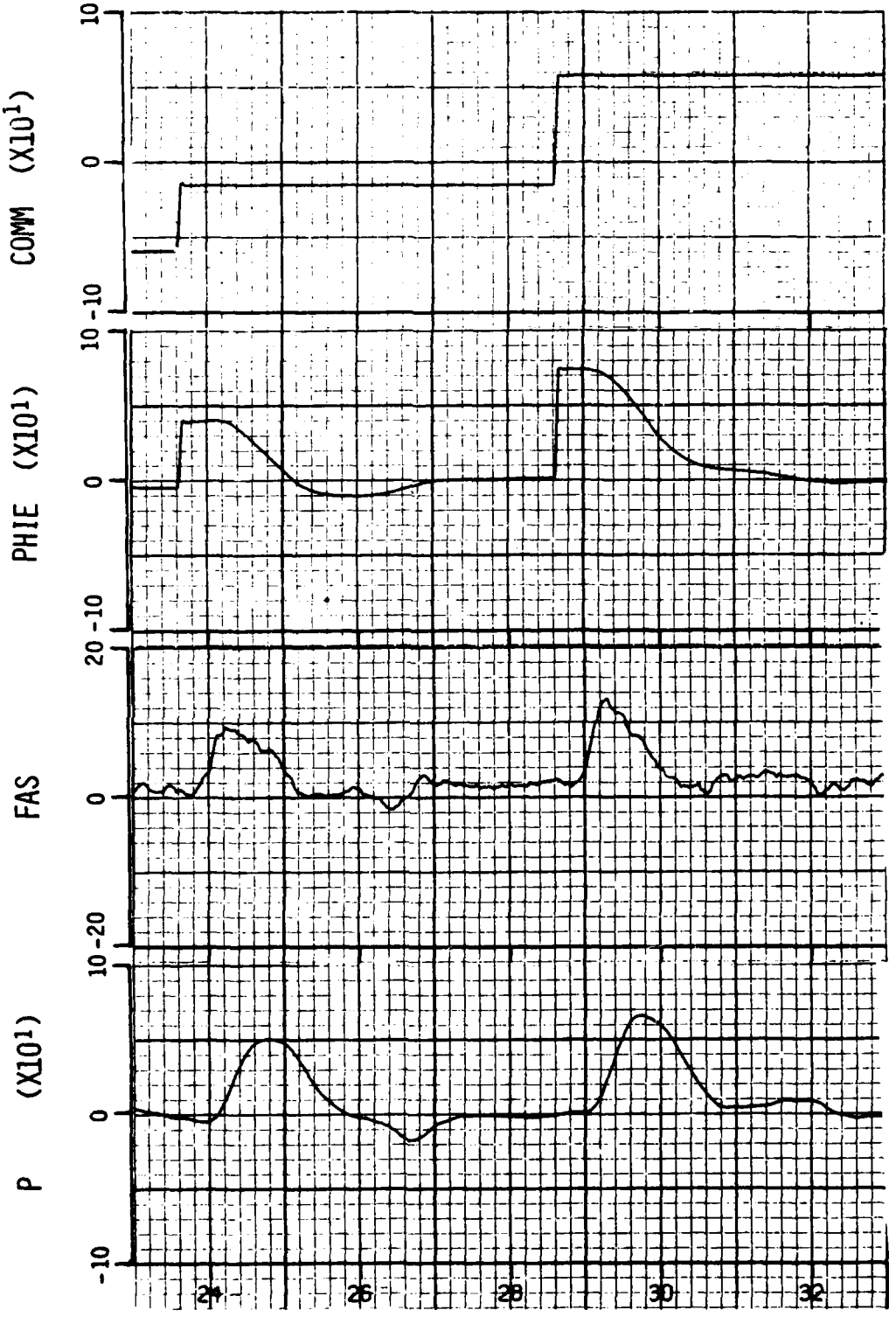


Figure E-4: BANK ANGLE TRACKING TASK (HUD) [PR = 5]
CONFIGURATION: 2-2, EVALUATION NO. 34

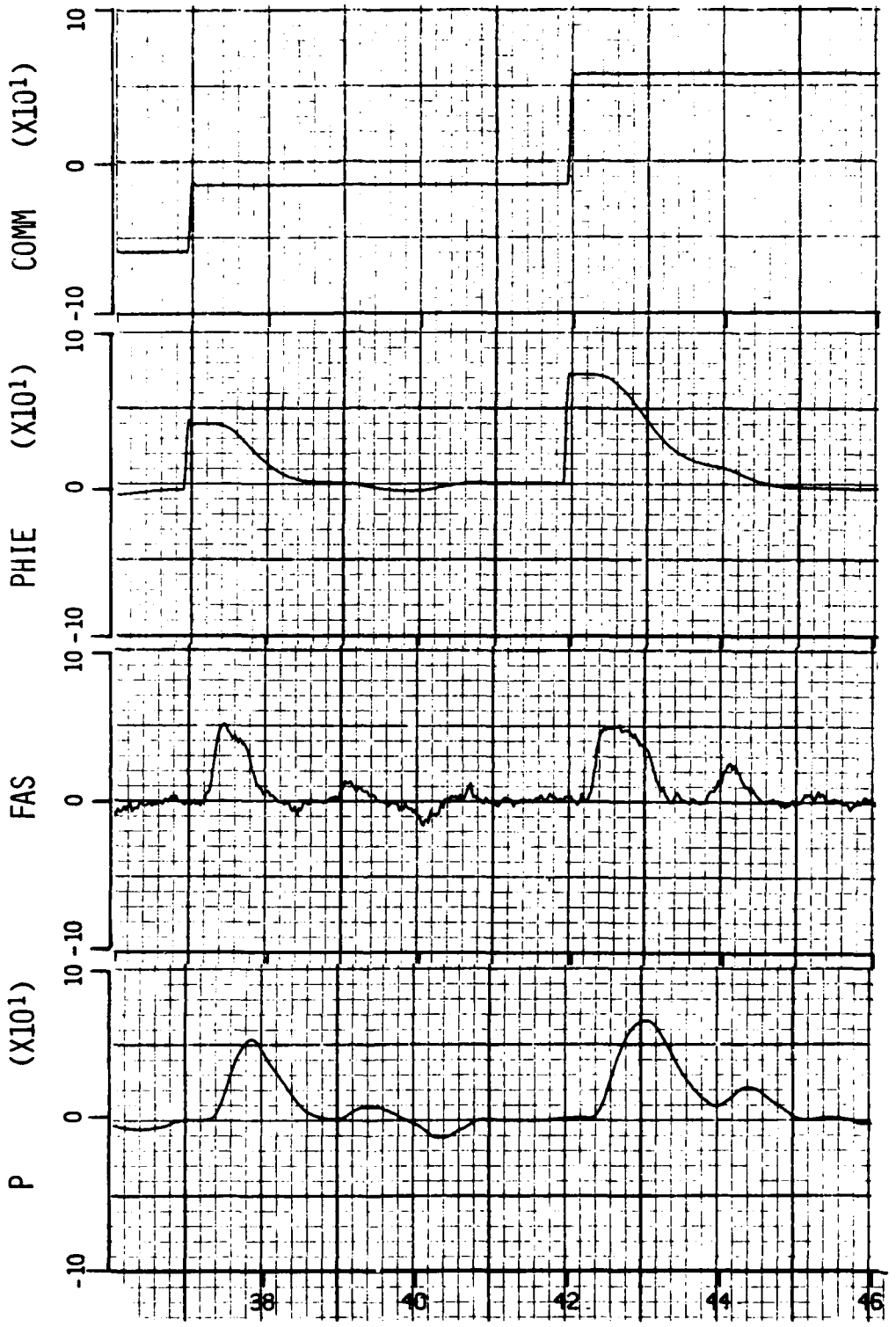


Figure E-5: BANK ANGLE TRACKING TASK (HUD) [PR = 3]
CONFIGURATION: 2-3, EVALUATION NO. 117

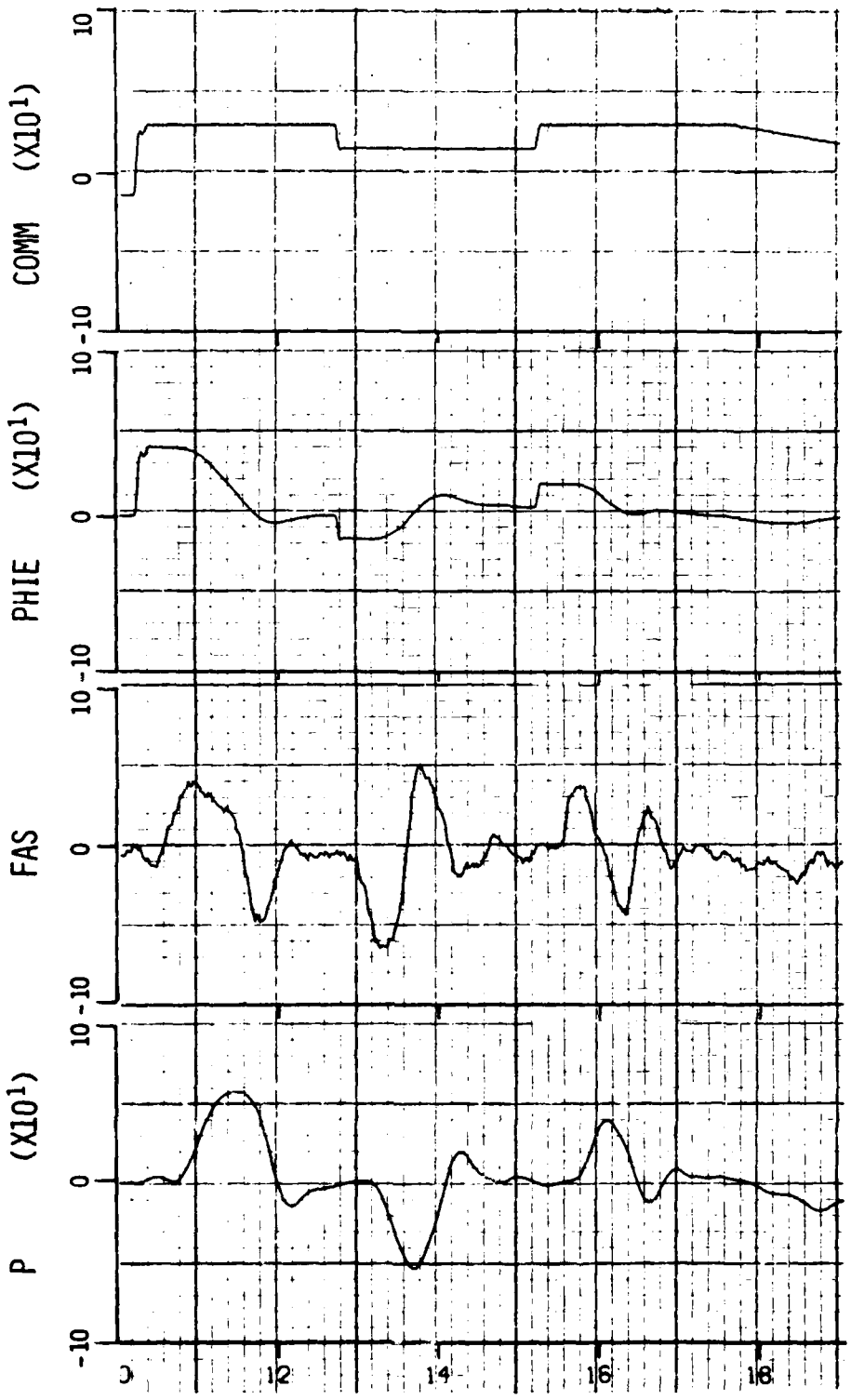


Figure E-6: BANK ANGLE TRACKING TASK (HUD) [PR = 3]
CONFIGURATION: 2-3T1, EVALUATION NO. 123

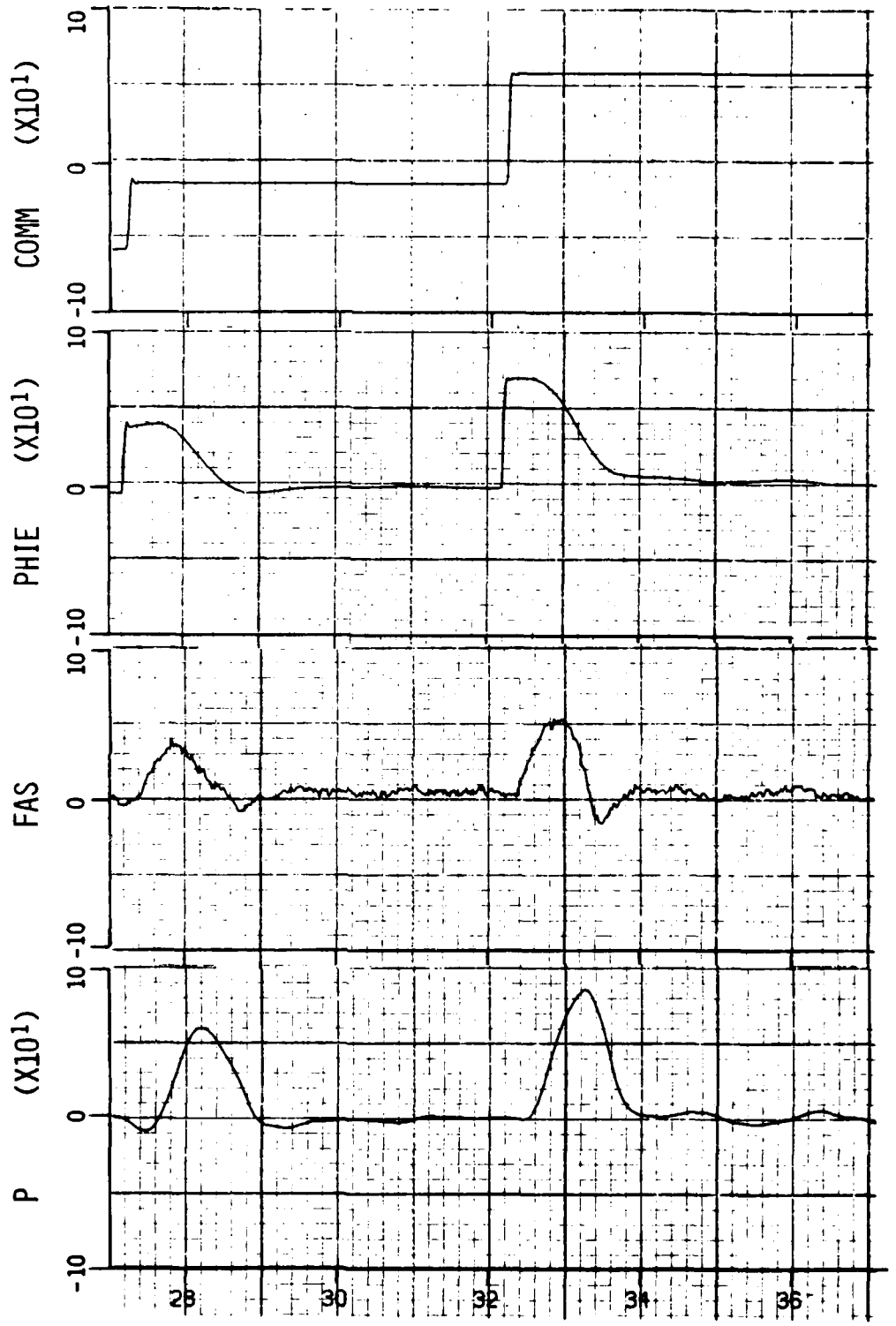


Figure E-7: BANK ANGLE TRACKING TASK (HUD) [PR = 3]
CONFIGURATION: 2-4, EVALUATION NO. 124

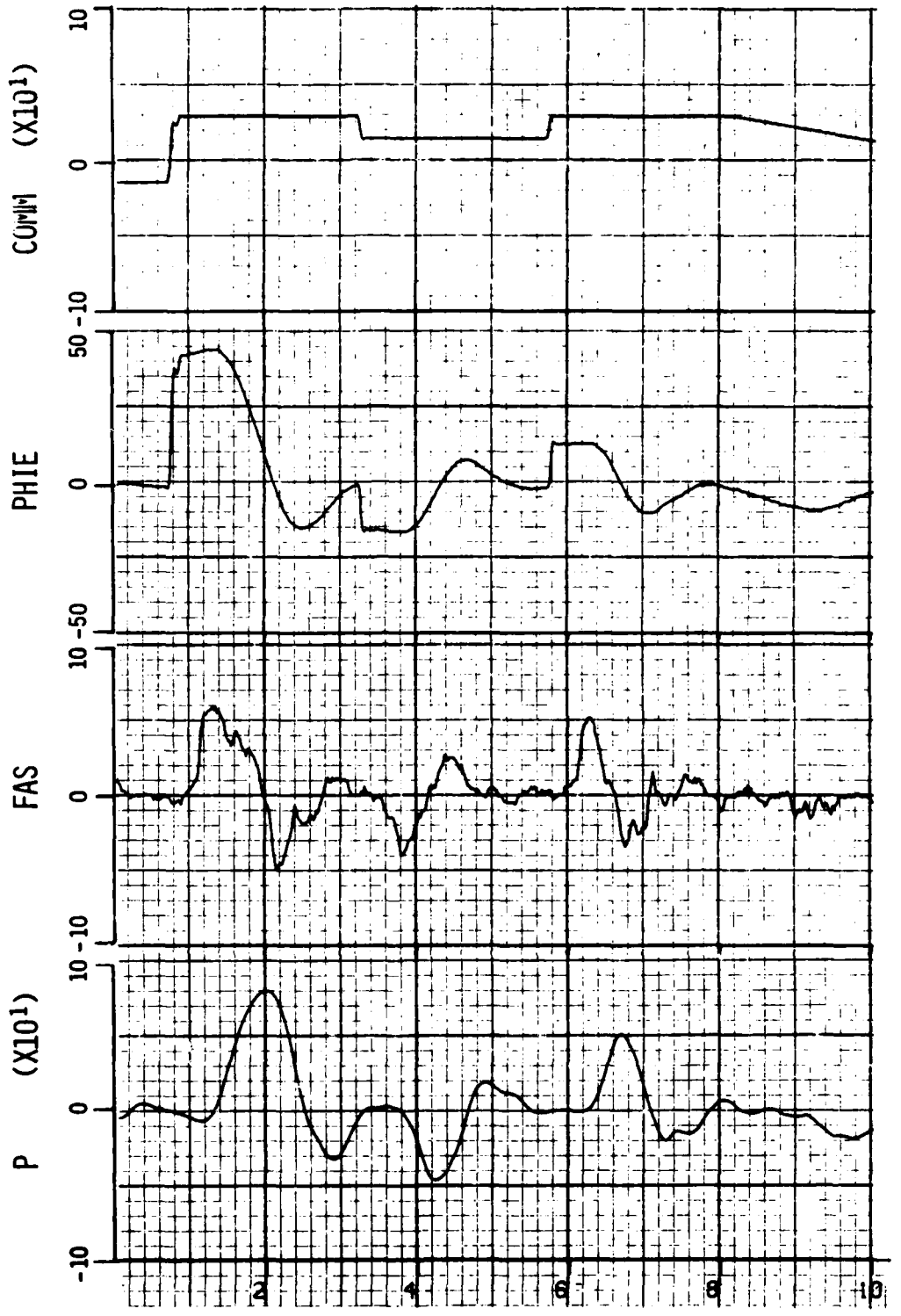


Figure E-8: BANK ANGLE TRACKING TASK (HUD) [PR = 9]
CONFIGURATION: 2-4T3, EVALUATION NO. 35

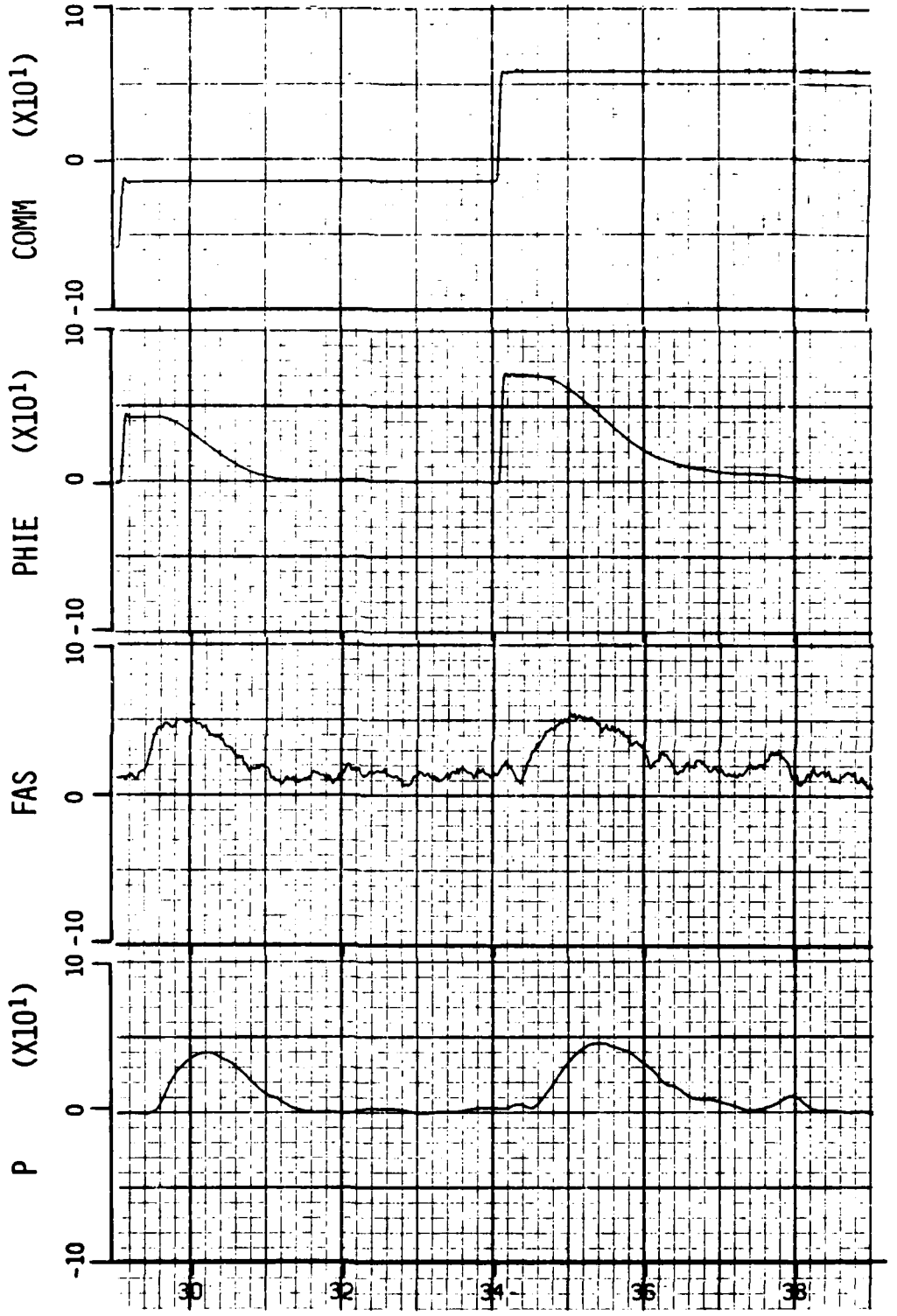


Figure E-9: BANK ANGLE TRACKING TASK (HUD) [PR = 4]
CONFIGURATION: 3-2, EVALUATION NO. 42

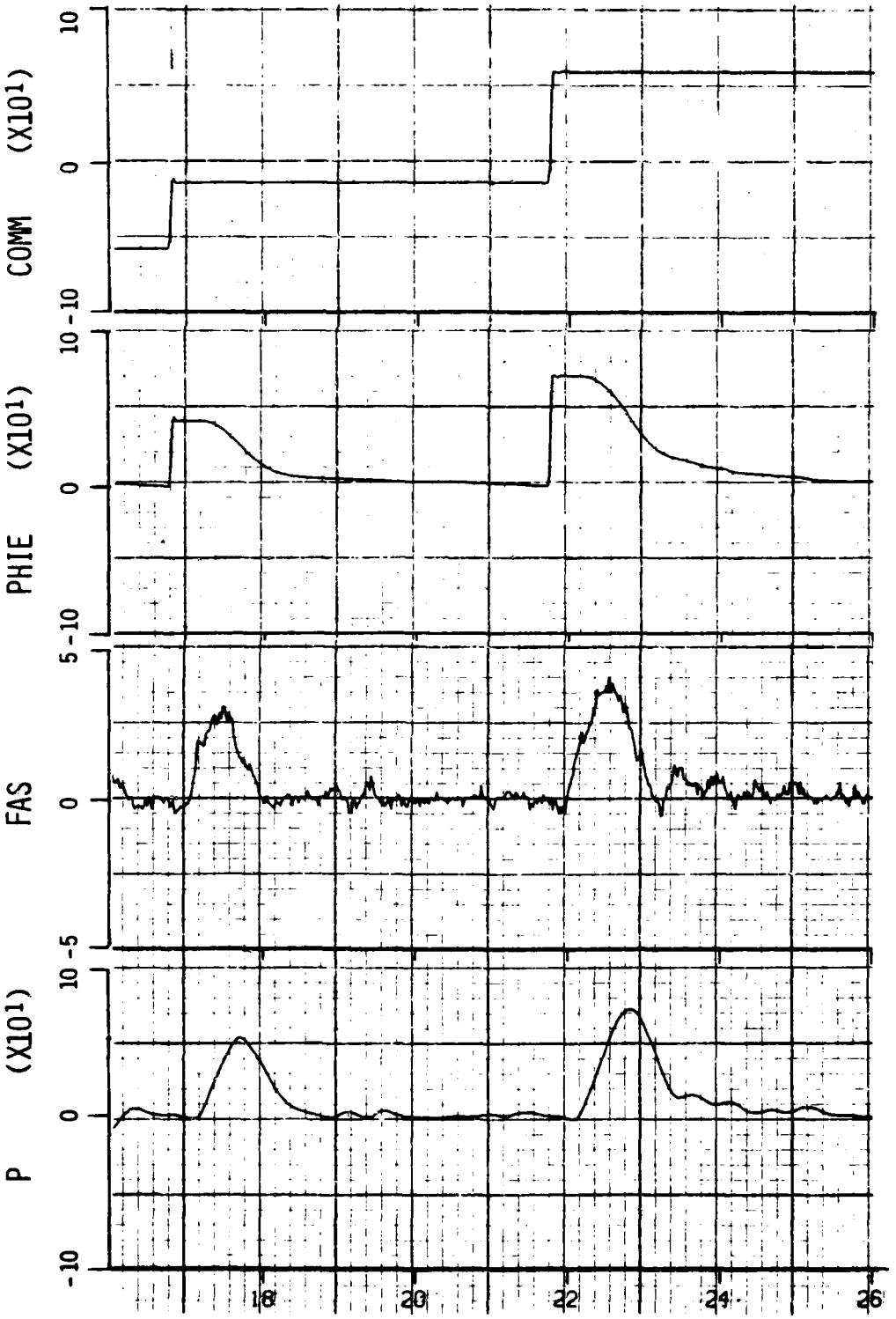


Figure E-10: BANK ANGLE TRACKING TASK (HUD) [PR = 5]
CONFIGURATION: 3-3, EVALUATION NO. 44

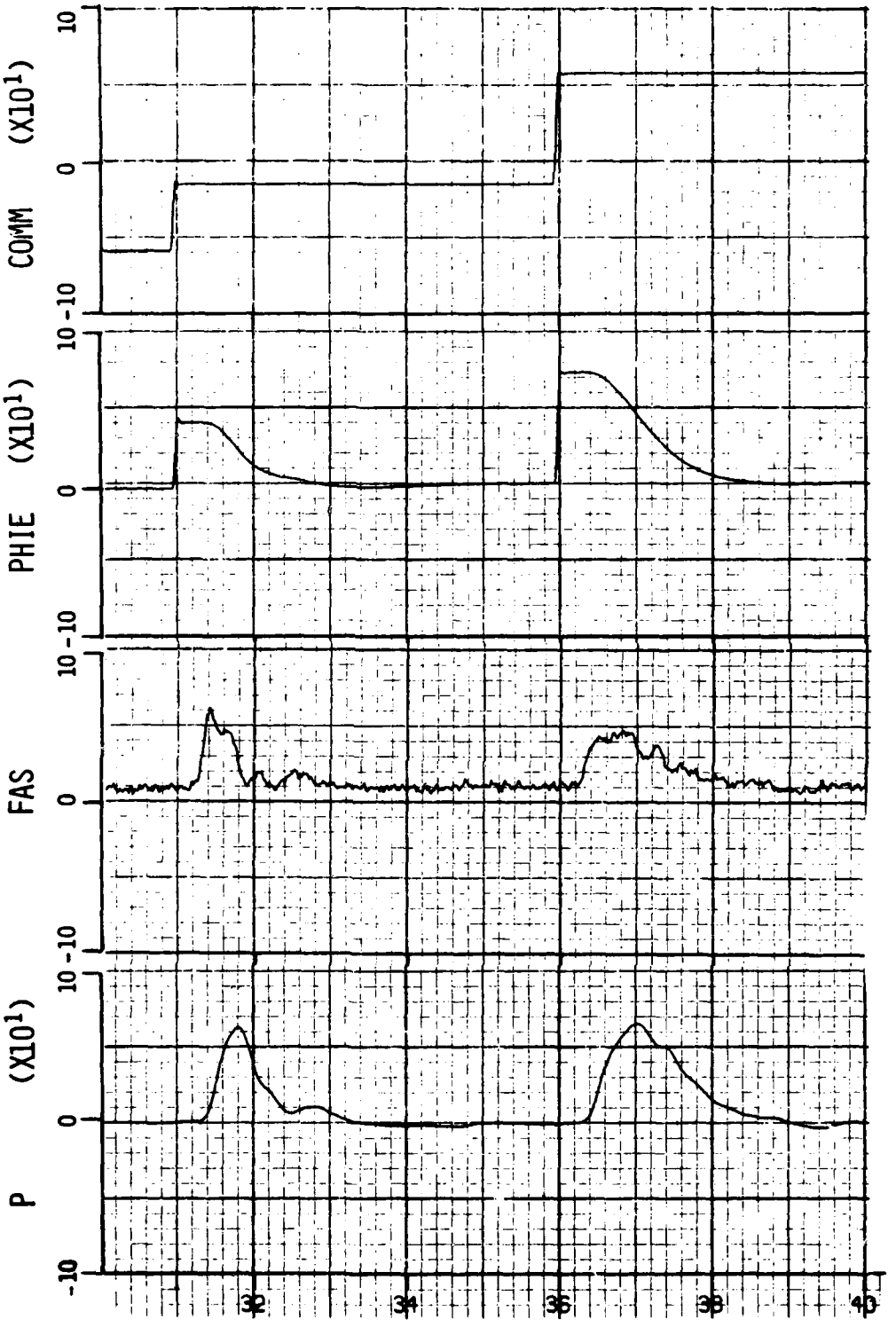


Figure E-11: BANK ANGLE TRACKING TASK (HUD) [PR = 4]
CONFIGURATION: 3-3, EVALUATION NO. 119

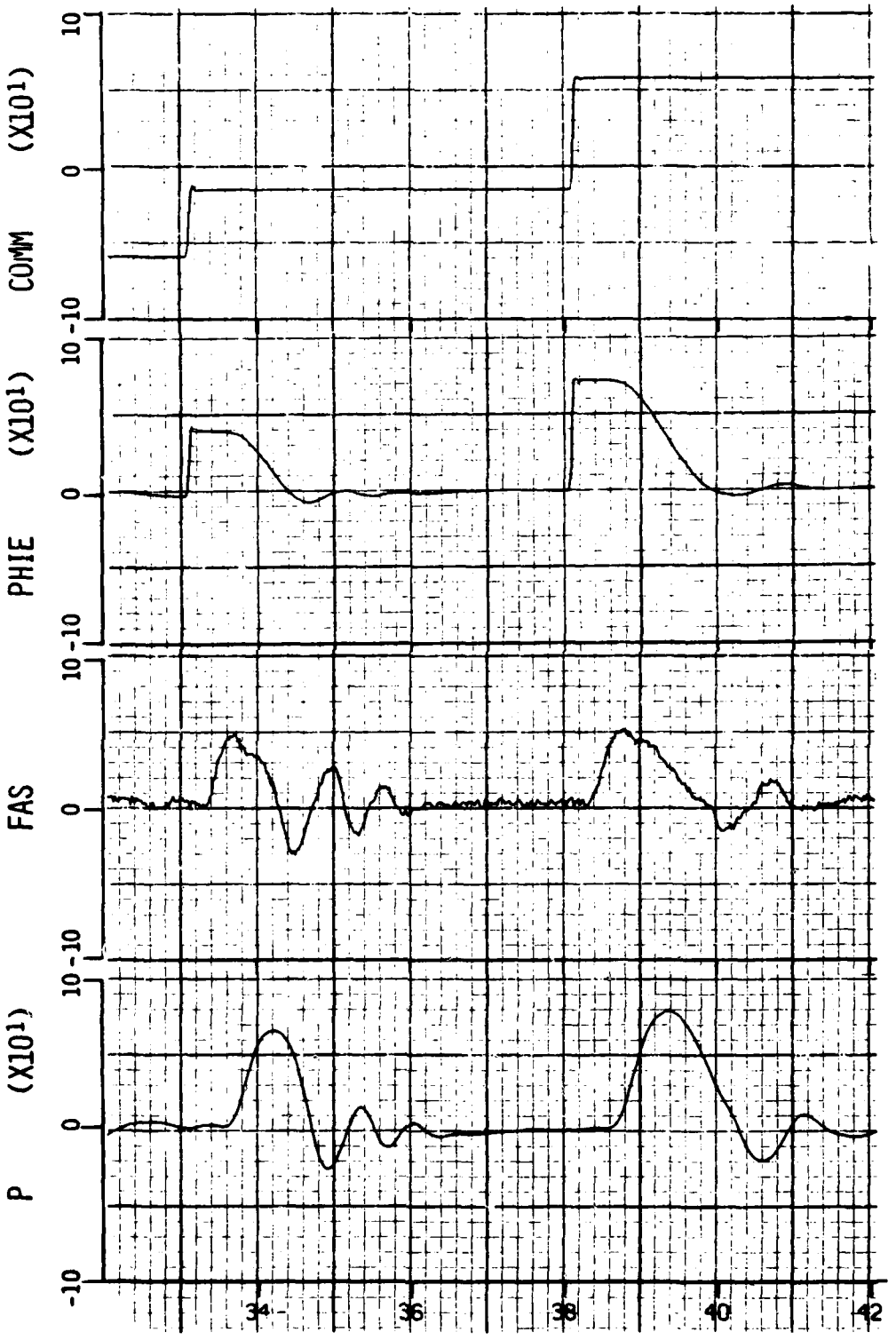


Figure E-12: BANK ANGLE TRACKING TASK (HUD) [PR = 7]
CONFIGURATION: 3-3T1F1, EVALUATION NO. 125

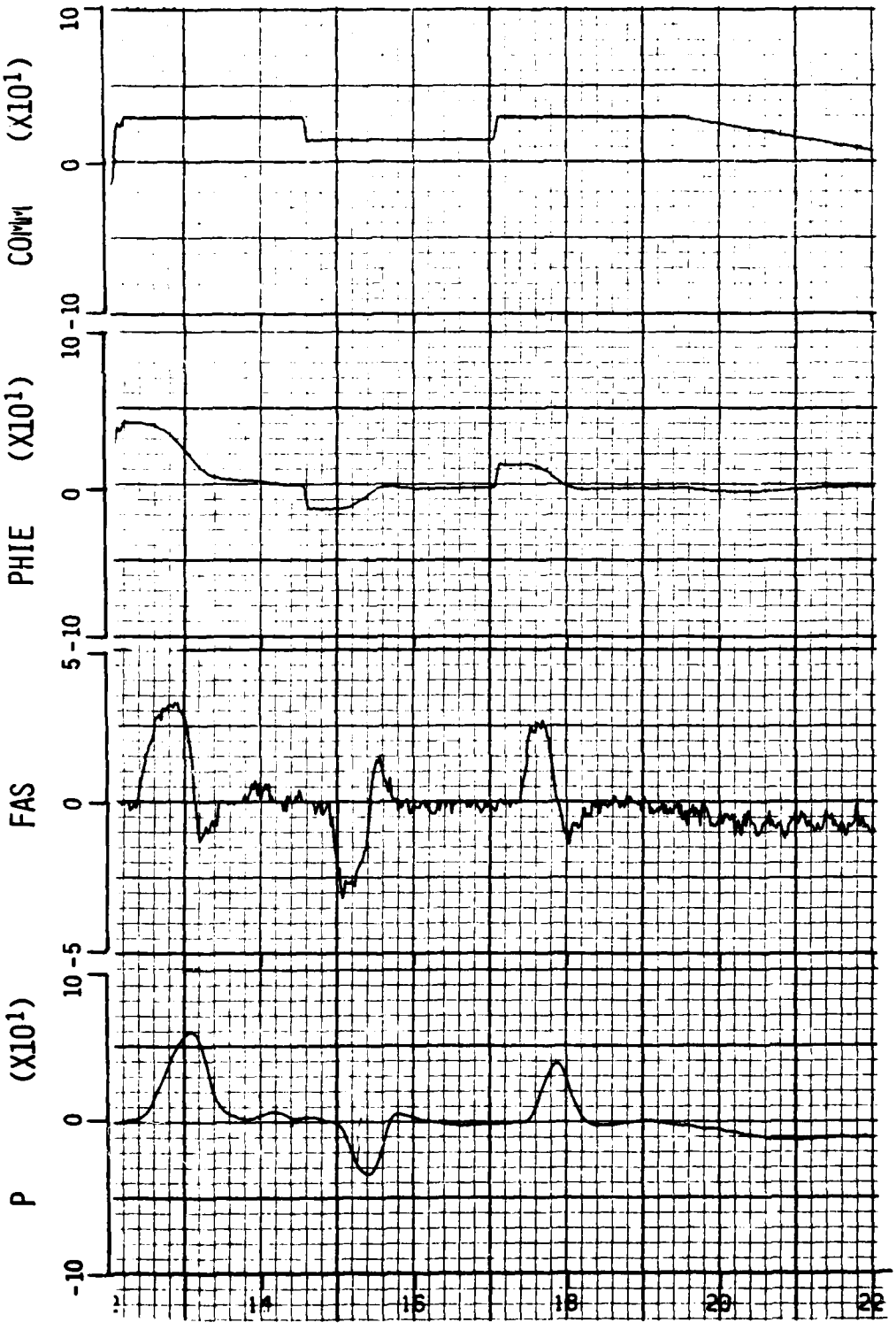


Figure E-13: BANK ANGLE TRACKING TASK (HUD) [PR = 2]
CONFIGURATION: 3-3D2, EVALUATION NO. 162

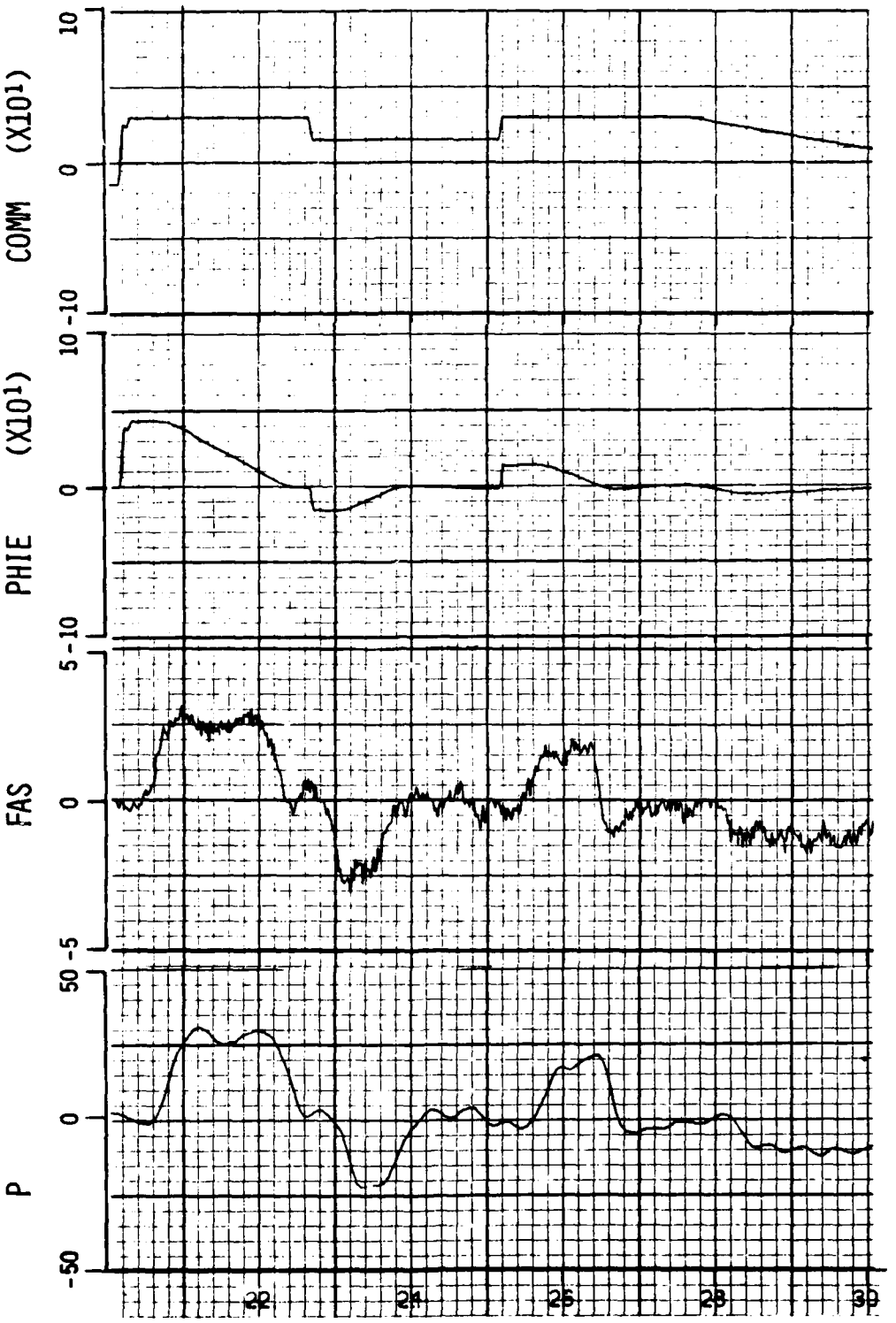


Figure E-14: BANK ANGLE TRACKING TASK (HUD) [PR = 7]
CONFIGURATION 5-2, EVALUATION NO. 12

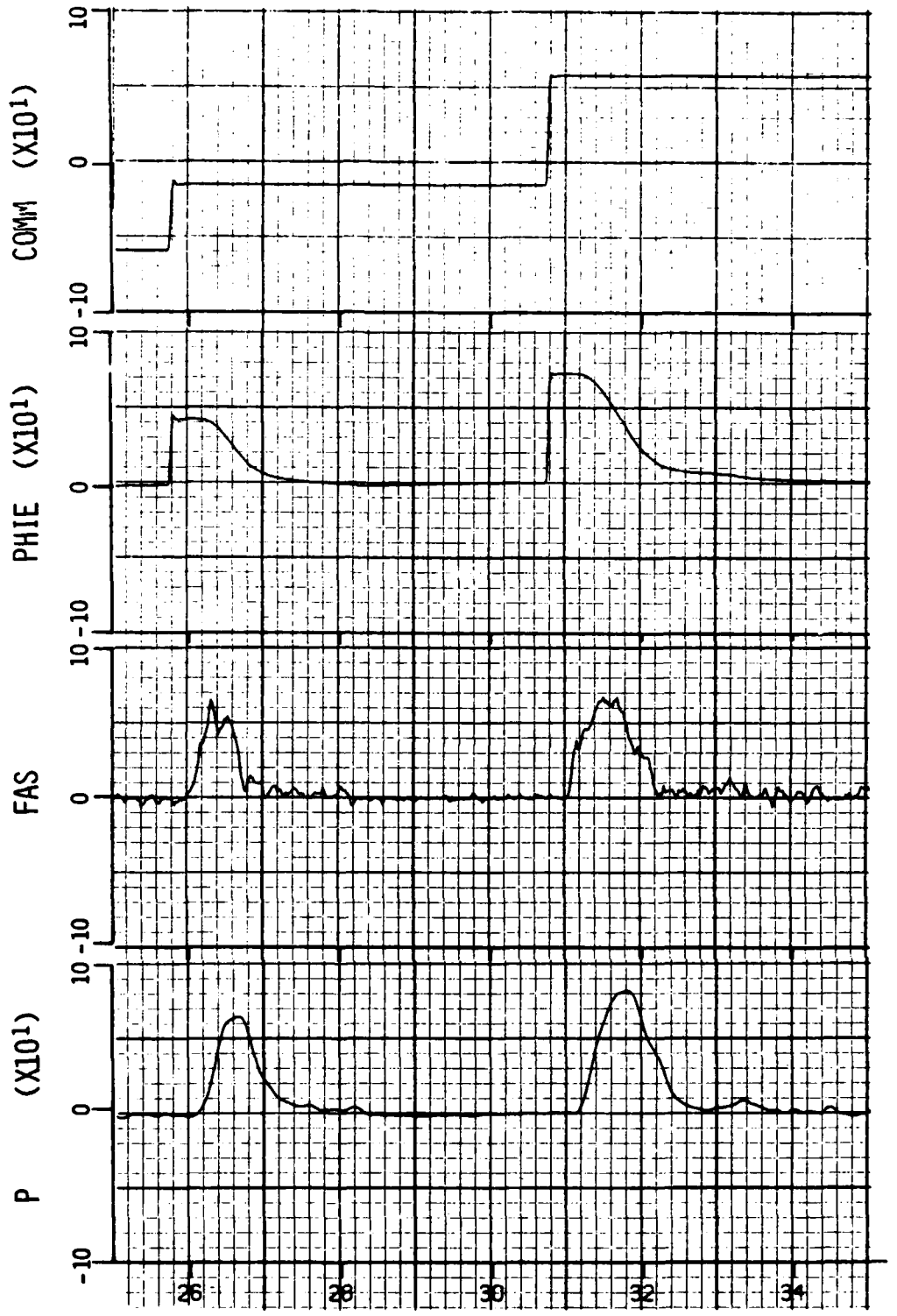


Figure E-15: BANK ANGLE TRACKING TASK (HUD) [PR = 7]
CONFIGURATION: 5-3, EVALUATION NO. 36

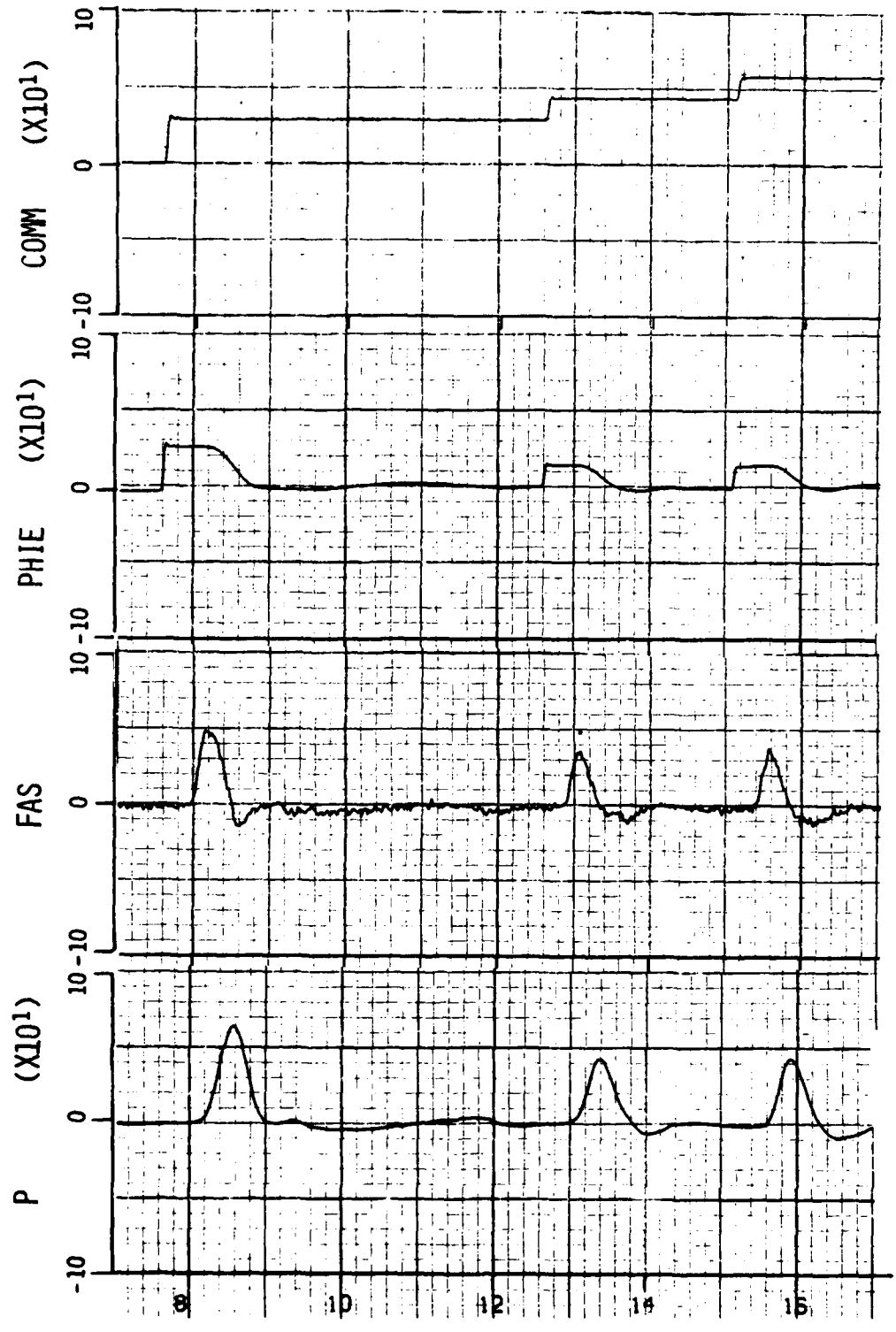


Figure E-16: BANK ANGLE TRACKING TASK (HUD) [PR = 7]
CONFIGURATION: 5-3 T1F1, EVALUATION NO. 120

APPENDIX F

OTHER CORRELATIONS OF THE RESULTS

This appendix correlates the results of this experiment with applicable flying qualities data, criteria, and analyses. Unless specified to the contrary, averaged pilot ratings are used to describe a configuration's flying qualities. For Flight Phase Category A configurations, the pilot rating data from the gun tracking and aerial refueling tasks are combined. HUD tracking task evaluations are included only if no other evaluations of that configuration were performed. Evaluations of nonlinear gradient and maximum Dutch roll damping configurations are not addressed in these correlations.

Initial efforts to apply the Neal-Smith pilot-in-the-loop analysis technique to the lateral data from this experiment were inconclusive. A more thorough analysis of this correlation method is beyond the scope of this report but does merit further investigation.

Comparison of Experiment Results With Other Data:

The results from this experiment are compared to other flying qualities data in this section. The only data on hand for this exercise were generated during an in-flight experiment to verify the Equivalent Systems concept and, also to investigate landing and approach fighter aircraft flying qualities (Reference 9). The results are generally applicable to the design of highly augmented fighter aircraft for the approach and landing task but the data should be viewed as preliminary due to the exploratory nature of the experiment and its compressed flight schedule. The lateral portion of the Equivalent Systems Program (ESP) experiment results are compared to the Flight Phase Category C data from this experiment as follows:

- Equivalent Time History Parameters:

The results of this experiment correlate remarkably well with effective roll response characteristics derived from roll rate, step response time histories (Section 6). This same analysis is performed on the ESP results (Figure F-1). The pilot rating level boundaries from Figure 6-4 are superimposed on the figure. The correlation of the ESP data indicates that the ESP results are consistant as a set against these equivalent system parameters. In comparison with the results from this experiment, however, significant differences are apparent in the degradation of flying qualities as the effective roll mode and effective time delay increase. Although no definitive conclusions can be drawn from this comparison the ESP results show a greater tolerance to the effective parameters. This is believed to be due to the task being less stringent. The different nominal prefilters in each experiment's roll control system (20 rad/sec break frequency versus 40 rad/sec for this experiment) may have also had an effect. Further analysis should be undertaken to investigate this comparison. More reliance should, however, be placed on the data and results of this report.

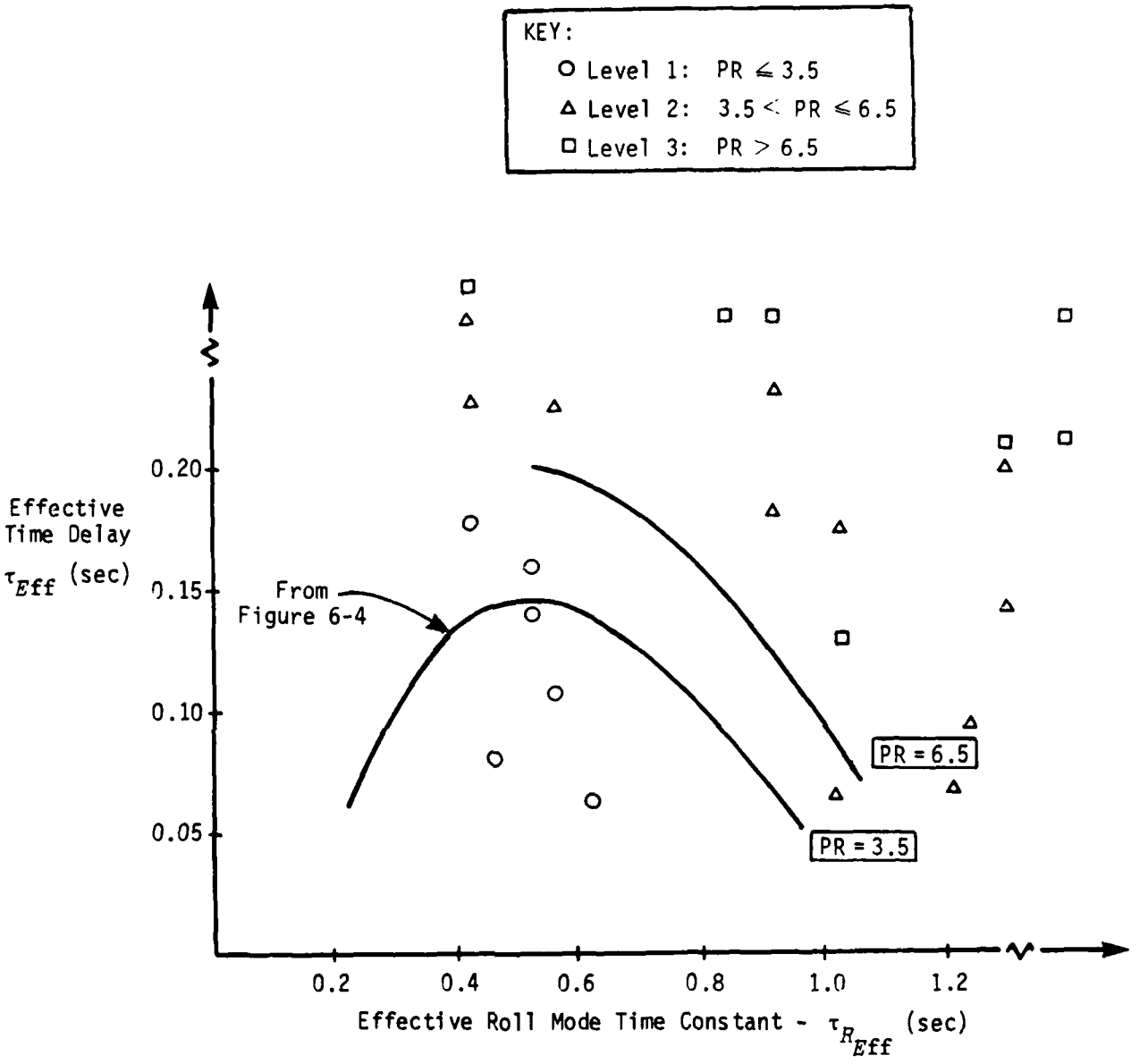


Figure F-1: ESP DATA, EFFECTIVE ROLL MODE AND TIME DELAY CORRELATION

- Effects of Time Delays:

The results from this program show that time delay degrades lateral landing and approach fighter flying qualities severely; the degradation of flying qualities with time delay for this flight phase has been estimated by using the equivalent time delay parameter:

- Total Time Delay Threshold: ≈ 120 *ms*
- Slope After Threshold: ≈ *1 PR/30 msec*

For the Equivalent Systems Program, the effect of time delay added to a baseline configuration was approximately:

- Total Time Delay Threshold: ≈ 220 *ms*
- Slope After Threshold: ≈ *1 PR/30 msec*

The rates at which flying qualities degrade due to additional time delay above the threshold are the same from each experiment. However, the threshold value for the ESP program is significantly higher than for this experiment. This difference may be related to the differences in task or nominal roll prefilter between the two experiments; further investigation is required.

Comparison With MIL-F-8785C Requirements:

In this section, several requirements from the current military specification for piloted airplane flying qualities (MIL-F-8785C; Reference 2) are applied to the configurations from this experiment.

Three pertinent requirements from the military specification were applied to the experiment configurations: roll response, phase lag and time delay. Additional requirements were not used because the specifications were either not applicable to this experiment and evaluation tasks, or because all the configurations met a particular requirement. For example, the roll mode time constant of each configuration is within the Level 1 limits and is not included in this analysis. On the other hand, the roll control effectiveness and roll control force requirements are not applied to these data since the evaluation tasks did not require aircraft maneuvers which approached those needed to show compliance.

Table F-1 and Table F-2 compare each configuration to the three military specification requirements for Flight Phase Category A and C, respectively. Also tabulated are the evaluated flying qualities levels of each case based on averaged pilot ratings. Assume that a specification failure is defined as predicting the flying qualities of a configuration to be better than evaluated. The three requirements correctly predict 75% of the configuration flying qualities. However, several configurations point out potential deficiencies in the specification requirements.

TABLE F-1: COMPLIANCE OF CONFIGURATIONS
(FLIGHT PHASE CATEGORY A)

Configuration	Roll Response Section 3.3.4.1.3	Allowable Phase Lag Section 3.5.3	Allowable Time Delay Section 3.5.3	Actual Pilot Rating Level	
1-2	1	1	1	2	X
1-3 1	1	1	1	1	
T1	1	2	1	3	X
T2	1	2	1-2	3	X
F2	1	3	1	2	
T0F7	1	1	1	2 (HUD)	X
2-2	1	1	1	1	
T1	1	2	1	1	
T2	1	2	1-2	2	
T3	1	2	2	3	X
T4	1	3	3	3	
F1	1	2	1	1	
F3	1	3	1	2	
T1F1	1	1	1	2	X
2-3	1	1	1	1	
T1	1	2	1	2	
T2	1	2	1-2	2	
T3	1	2	2	3	X
F1	1	2	1	1	
F2	1	3	1	1	
F3	1	3	1	3	
T1F1	1	1	1	2	X
T2F1	1	1	1	2 (HUD)	X
2-4	1	1	1	1	
T1	1	2	1	2	
T2	1	2	1-2	2	
T3	1	2	2	3	X
F1	1	2	1	1	
F2	1	3	1	1	
F3	1	3	1	3	
T1F1	1	2	1	3	X
T2F1	1	2-3	1-2	3	
3-2	1	1	1	1	
3-3	1	1	1	2	X
T2	1	2	1-2	3	X
T3	1	3	2	3	
F1	1	2	1	2	
F3	1	3	1	2	
F4	1	4	1	2	
F5	1	4	1	3 (HUD)	
T1F1	1	2-3	1	3	

TABLE F-1: COMPLIANCE OF CONFIGURATIONS
(FLIGHT PHASE CATEGORY A, CONT'D)

Configuration	Roll Response Section 3.3.4.1.3	Allowable Phase Lag Section 3.5.3	Allowable Time Delay Section 3.5.3	Actual Pilot Rating Level	
3-4	2	1	1	2	
T2	1	2	1-2	3	X
F1	1	2	1	1	
F3	1	3	1	2	
F4	1	4	1	2	
F5	1	4	1	3	
T1F1	1	2-3	1	3	
T2F1	1	3	1-2	3 (HUD)	
5-2	1	2	1	3	X
T1	1	3	1	3	
T3	1	3	2	3	
F1	1	3	1	2	
F2	1	3	1	2	
F3	1	4	1	2	
T1F1	1	3	1	3 (HUD)	
T0F6	1	3	1	2	
T1F6	1	3	1	2	
5-3	1	2	1	3	X
T1	1	3	1	3	
T2	1	3	1-2	3	
F1	1	3	1	1	
F3	1	4	1	1	
F5	1	4	1	3	
T1F1	1	3	1	3	
T2F1	1	4	1-2	3	
T1F6	1	3	1	3	

NOTE:

X Actual PR > Predicted PR (Failure)

● Correct Predictions 51/67 ∿ 76%

TABLE F-2

COMPLIANCE OF CONFIGURATIONS
(FLIGHT PHASE CATEGORY C)

Configuration	Roll Response Section 3.3.4.1.3	Allowable Phase Lag Section 3.5.3	Allowable Time Delay Section 3.5.3	Actual Pilot Rating Level	
L1-1	1	1	1	2	X
L1-2	1	1	1	1	
T1	1	1	1	1	
T2	1	1-2	1-2	2	
T3	1	2	2	3	X
T4	1	2-3	3	3	
F1	1	1	1	2	X
F2	1	2	1	3	X
T1F1	1	2	1	2	
L2-1	1	1	1	1	
T1	1	1	1	2	X
T2	1	2	1-2	2	
T4	1	2-3	3	3	
F1	1	1-2	1	1	
F3	1	3	1	1	
L2-2	1	1	1	1	
F1	1	1-2	1	1	
F2	1	2	1	1	
F3	1	3	1	3	
L3-1	1	1	1	1	
L3-2	1-2	1	1	1	
T2	1	2	1-2	2	
L4-1	1	1	1	2	X
T2	1	3	1-2	1	
F1	1	3	1	1	

NOTE:

X Actual PR > Predicted PR (Failure)

● Correct Predictions: 19/25 ∿ 76%

For example:

- Specification requirements from which "correct" prediction of flying qualities was achieved often do not intuitively relate to the commentary from the pilot evaluation. For example, 5-3T1 was rated Level 3 because of roll ratcheting problems but was correctly predicted Level 3 by the phase lag requirement. Since this example is not an isolated case, the success exhibited by the specification may be by coincidence rather than specific design of the requirements.

- Good flying qualities can be degraded in an effort to comply with the specification (e.g. 5-3F1 → 5-3). The evidence suggests that the phase lag requirement is overly stringent for short roll mode time constant cases. Other examples of similar problems are 2-3F2 and 3-4F4 which are predicted to have very poor flying qualities yet were rated borderline Level 1.

Tracking Task Performance - Statistical Analysis:

Several configurations were selected for statistical analysis of task performance during the HUD-based compensatory tracking tasks. Only the bank attitude tracking task was used in this analysis because it was more representative of the air-to-air gun tracking task. The HUD-based tracking tasks, provide all the piloting task components, including the commanded and achieved aircraft attitude. Portions of the tracking task flight records are presented in Appendix E.

The statistical task performance analysis was performed on flight data from the HUD tracking task after evaluations with target aircraft. Varying record lengths were used for the analyses. The configurations and corresponding statistics of this exercise are listed in Table F-3.

Several correlations were attempted with the statistical measures in an effort to correlate the task components with flying qualities. The results are inconclusive. Figure F-2 shows the correlation of two measures ($\phi_e = \phi_c - \phi$, and $N_{Y_{E.P.}}$) which were presumed to be important piloting task parameters. Some correspondence between linear acceleration at the pilot's eye reference point and evaluated flying qualities may be evident; however, the correlation is poor.

In an attempt to improve the statistical analysis, a standard portion of the HUD task was selected for analysis. Ten seconds of the HUD task consisting of two discrete step commands were used. In addition, the task performance statistic, time-on-target (TOT), defined as the total time in seconds for which the achieved bank angle was within 1.5 deg of the commanded bank angle, was calculated. The statistics from this analysis are given in Table F-4.

TABLE F-3: STATISTICAL ANALYSIS - HUD BANK ANGLE TRACKING TASK

Configuration:		1-3	3-3	3-2	2-2	2-4T3	5-3	2-3	3-3	5-3T1F1	1-3F2	2-3T1	2-4	3-3T1F1
Evaluation:		41	44	42	34	35	36	117	119	120	122	123	124	125
	$\bar{X}$	-0.15	-0.23	1.00	1.6	0.10	-0.2	-0.10	1.0	-0.2	-1.4	-0.78	0.45	0.26
F_{as}	σ	2.08	0.95	1.60	2.9	1.45	1.8	1.7	1.2	1.6	3.1	1.8	1.03	1.70
	rms	2.08	0.98	1.90	3.3	1.45	1.8	1.7	1.6	2.8	3.5	1.9	1.10	1.70
	$\bar{X}$	1.63	2.60	3.9	1.8	2.0	1.3	0.8	2.1	1.3	1.2	1.6	2.3	4.0
F_{es}	σ	3.62	3.13	3.1	3.1	2.7	2.2	3.0	2.6	2.4	2.9	2.3	2.9	3.1
	rms	3.97	6.10	5.0	3.5	3.4	2.6	3.1	3.4	2.8	3.2	2.8	3.7	5.0
	$\bar{X}$	-6.25	-5.71	-0.3	-4.9	-2.2	-1.8	-5.4	2.7	-6.5	-7.5	-5.6	-6.2	-9.4
F_{rp}	σ	3.87	2.04	4.2	1.2	0.7	1.2	6.4	4.6	3.4	5.8	4.0	3.2	5.1
	rms	7.35	6.07	4.2	5.0	2.3	2.2	8.4	5.3	7.3	9.5	6.8	7.0	10.7
	$\bar{X}$	1.00	2.35	1.1	1.9	1.2	-1.1	-1.0	1.2	-4.1	-0.4	-0.5	-1.1	0.40
ϕ_e	σ	19.5	17.2	19.3	17.5	13.1	19.3	17.9	18.7	21.4	20.4	16.9	17.1	18.7
	rms	19.5	17.38	19.3	17.6	13.1	19.4	18.0	18.8	21.8	20.4	16.9	17.1	18.7
	$\bar{X}$	0.03	0.02	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.02
$N_{Y_{EP}}$	σ	0.06	0.06	0 05	0.07	0.09	0.08	0.07	0.07	0.10	0.07	0.08	0.07	0.11
	rms	0.07	0.06	0.06	0.07	0.09	0.08	0.07	0.07	0.11	0.07	0.08	0.073	0.11
	$\bar{X}$	0.03	0.02	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.020	0.02
$N_{Y_{CG}}$	σ	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.016	0.02
	rms	0.03	0.02	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.03	0.02	0.025	0.03
	$\bar{X}$	-0.90	-0.39	-0.9	-1.0	-0.6	0.6	-0.6	-0.4	-0.30	-0.30	-0.5	-0.60	-0.76
β	σ	0.32	0.27	0.25	0.35	0.4	0.4	0.3	0.3	0.45	0.45	0.30	0.30	0.36
	rms	0.96	0.47	1.0	1.0	0.71	0.8	0.7	0.5	0.50	0.54	0.60	0.64	0.84
Record Length (Sec)		34	28	48	38	24	46	58	40	28	32	32	58	48

$\bar{X}$ = Mean
σ = Standard Deviation
rms = Root Mean Square Value

$\phi_e = \phi_c - \phi$

$N_{Y_{EP}}$ - Lateral acceleration at pilot eye pilot (g's)

$N_{Y_{CG}}$ - Lateral acceleration at aircraft center of gravity (g's).

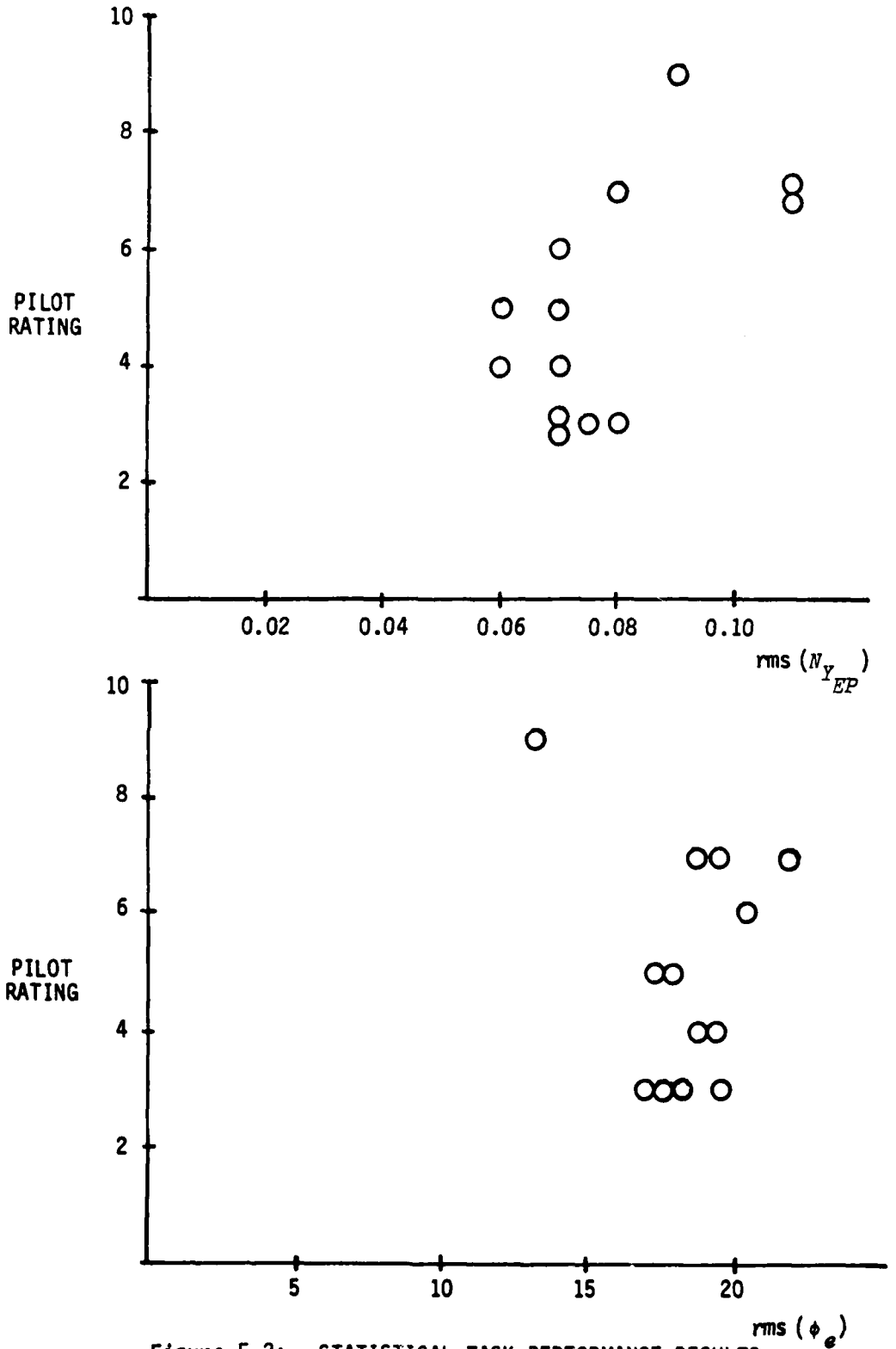


Figure F-2: STATISTICAL TASK PERFORMANCE RESULTS

Figure F-3 shows the correlation of task performance (measured by time-on-target and the root mean square value of bank angle error) with flying qualities. One would expect from this correlation that configurations which were evaluated as having good flying qualities would correspond to high time-on-target and low rms error values. Conversely, poor flying qualities would theoretically relate to high rms error and low time-on-target statistics. As evident from the figure, little correspondence can be seen. Additional configurations were not analyzed because of these poor initial results.

In summary, the limited analysis of various statistical data did not uncover any correlating parameters.

TABLE F-4: TASK PERFORMANCE STATISTICAL ANALYSIS

Configuration	Evaluation Number	TOT	ϕ_e			$N_{Y_{EP}}$		
			$\bar{X}$	σ	*rms*	$\bar{X}$	σ	*rms*
2-2	34	2.60	13.9	23.8	27.5	0.030	0.065	0.075
5-3	36	3.85	13.1	21.1	24.9	0.030	0.090	0.095
1-3	41	3.30	16.9	22.8	28.4	0.025	0.045	0.055
3-2	42	2.80	17.9	22.5	28.7	0.035	0.040	0.055
2-3F3	43	1.70	23.3	22.7	32.5	0.015	0.025	0.030
3-3	44	3.55	13.4	21.5	25.3	0.015	0.070	0.070
2-3	117	2.30	13.0	22.6	26.1	0.025	0.070	0.075
3-3	119	4.25	13.1	22.5	26.0	0.020	0.075	0.075
2-4	124	1.60	10.5	21.2	23.7	0.020	0.090	0.090
3-3T1F1	125	4.35	12.7	23.2	26.5	0.025	0.100	0.105

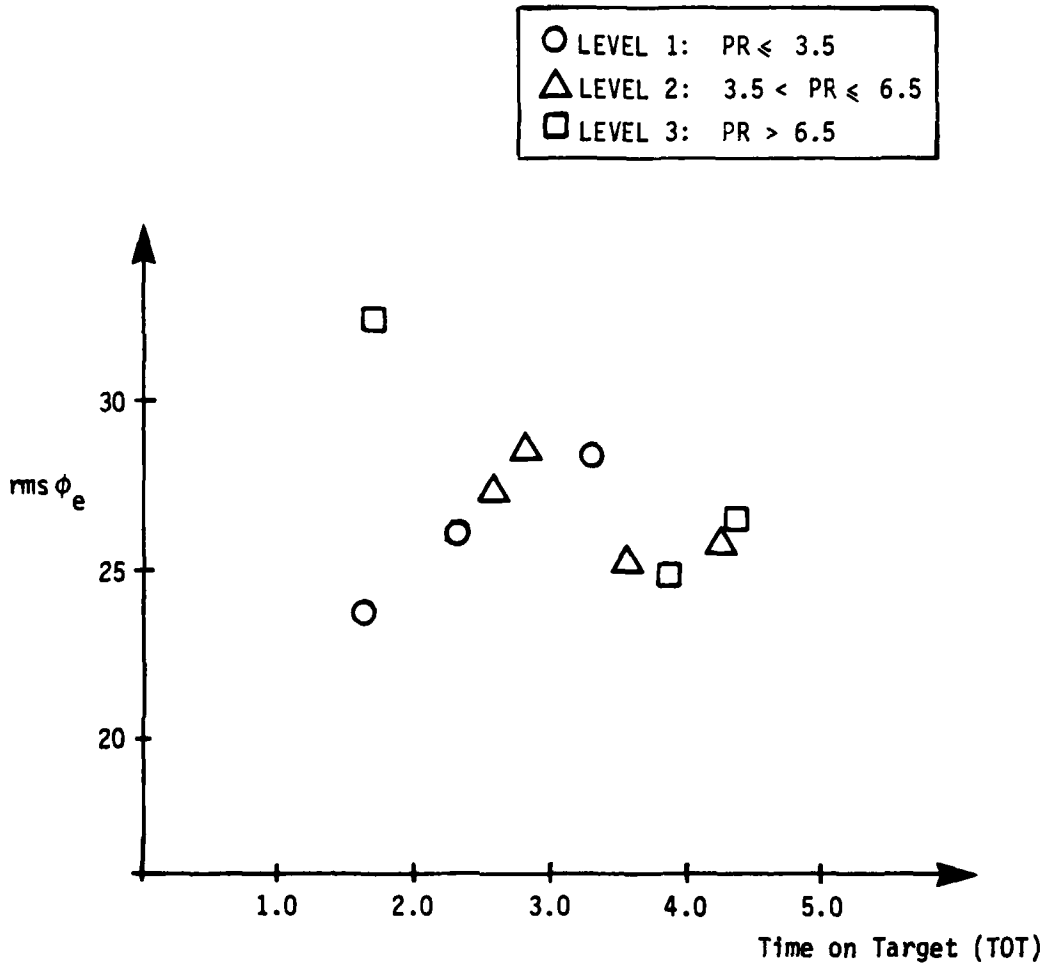


Figure F-3: CORRELATION OF TASK PERFORMANCE STATISTICS WITH SELECTED LATHOS CONFIGURATIONS FLYING QUALITIES

APPENDIX G

CONFIGURATION CHARACTERISTICS

This appendix documents and describes the simulated aircraft configuration characteristics. Details of the simulation mechanization using the variable stability NT-33A aircraft are provided in Appendix I.

The simulated augmented aircraft characteristics are illustrated (Figure G-1) using a simplified block diagram of a configuration's individual components. The force command control system shown in the figure was implemented in each control axis. The individual components of the longitudinal and lateral-directional aircraft configurations are presented in this appendix. The "total" simulated configuration characteristics and aircraft transfer functions are formed by combining the individual components.

The control system components and augmented aircraft dynamics were calibrated and/or identified using appropriate methods prior to the start of evaluation flying. These calibrations were repeated periodically throughout the evaluation flying phase to verify that nothing changed. Calibration of the feel system, control system, and actuator dynamics was performed on the ground by static, step response, and frequency response measurements of each individual element. Where possible these calibrations were checked in flight.

The desired augmented aircraft dynamics were calibrated in flight using standard flight test data reduction techniques (Reference 18) and an onboard digital flight recorder. Aircraft responses to pilot step, pulse, and doublet control inputs were recorded for this purpose during five dedicated calibration flights. Since this experiment was an investigation of lateral flying qualities, additional identification techniques were employed to identify completely the lateral augmented aircraft configuration as outlined in the next subsection.

Augmented Lateral-Directional Aircraft Dynamics:

The desired lateral-directional augmented aircraft dynamics were achieved by feeding back the appropriate signals to the NT-33A control surfaces through the NT-33A's variable stability system. The required feedbacks and feedback gains were determined during the five flight calibration phase prior to the evaluation flying phase. It should be noted that the evaluation pilot had no knowledge of the simulated configurations nor did he feel the actions of the NT-33 feedback system in creating the augmented aircraft responses. To ensure that the lateral augmented aircraft dynamics were calibrated correctly and properly implemented, additional steps were taken during the evaluation flying phase. These included calibration records after evaluations, digital parameter identification, and fast Fourier Transformation analysis.

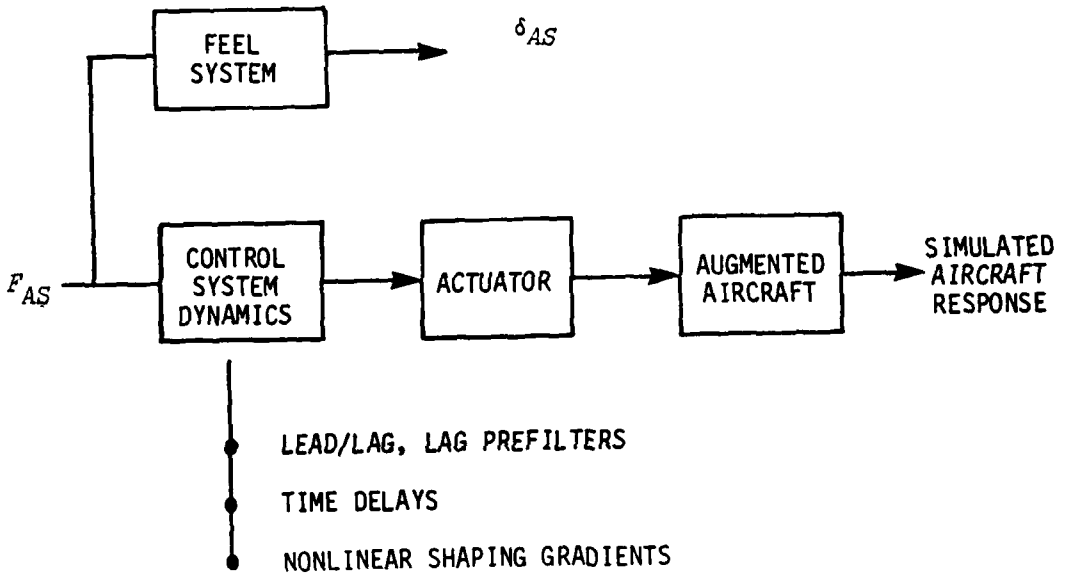


Figure G-1: BLOCK DIAGRAM OF SIMULATED AIRCRAFT CONFIGURATION CHARACTERISTICS

- Calibration Records After Evaluation:

At the end of each evaluation, lateral calibration records, identical to those taken during the calibration flying phase, were recorded for identification of the evaluated lateral configuration characteristics. Unfortunately, digital flight recorder failure negated this additional analysis on the last six flight (Flights 2507 through 2512). The calibration data, when available, were designed to validate the baseline augmented aircraft dynamics as well as the control system dynamics of the evaluated configuration. Overall, the configuration characteristics derived from these calibration records compared favorably with those characteristics determined during the initial calibration flights. Evaluations whose dynamics deviated significantly were rejected from the data base (Appendix A).

- Digital Parameter Identification:

Two flights were also flown during the evaluation phase to generate data for parameter identification of the lateral baseline augmented aircraft configurations. The parameter identification results served as the "final" determination of the lateral augmented aircraft configurations since the feedback gain schedules were frozen a this point and were not changed by the parameter identification "answers." The identification process, therefore provides an accurate three-degree-of-freedom model for the simulated lateral-directional configurations, if other than nominal dynamics are needed by the analyst.

A general purpose Bayesian Maximum Likelihood (BML) state estimation/parameter identification computer program (Reference 19) was used to identify the baseline lateral-directional augmented aircraft configurations. Tables G-1 through G-4 present the parameter identification models for the four baseline configurations from Flight Phase Category A (Configurations 1-3, 2-2, 3-2, and 5-2). Tables G-5 through G-8 are the identified landing and approach configuration models (Configurations L1-2, L2-4, L3-1, and L4-1). The transfer functions for the remaining baseline configurations of the same roll mode time constant, but different steady state roll rate per unit stick force (p_{SS}/F_{AS}), are formed by multiplying the lateral stick force numerators by the required increment in lateral command gain.

For example, the transfer functions for Configuration 2-3 are developed by multiplying the identified numerator polynomials of (p/F_{AS}, r/F_{AS}, and V/F_{AS}) for Configuration 2-2 by the factor 1.8. The rudder pedal force numerator polynomials and characteristic equation for Configuration 2-3 are identical to Configuration 2-2. The control inputs in each table (D1 and D2) are lateral stick force (F_{AS} - lb) and rudder pedal force (F_{RP} - lb), respectively. All angular measurements are in radians, unless specified to the contrary and velocities are in feet per sec.

The parameter identification models are based on data generated for the configurations at, or near, their normally flown fuel remaining state. Scheduling of the NT-33A's feedback gains as a function of fuel load was required

********** EQUATIONS OF MOTION********

		V*	V	P*	P	PHI		R*	R	F_{AS}	F_{RP}	D3
V	0.0	1.00E+00	1.85E-01	0.0	-1.11E+01	-3.22E+01	0.0	0.0	5.70E+02	1.20E-02	1.00E-03	0.0
L	0.0	0.0	1.66E-02	1.00E+00	1.27E+00	0.0	0.0	0.0	-1.30E+00	3.65E-01	-1.54E-03	0.0
N	0.0	0.0	-1.84E-02	0.0	5.40E-02	0.0	0.0	1.00E+00	1.76E+00	2.16E-02	3.32E-03	0.0

OUTPUT FORMAT :

THE CHARACTERISTIC EQUATION IN DESCENDING POWERS OF S

1.0000E+00 3.2207E+00 1.3531E+01 1.4880E+01 1.7090E-01

MODE RATIOS (EIGENVECTORS)

REAL	IMAGINARY	ZETA	OMEGA	TAU	PHI /V	PHI -DEG	R /V	R -DEG
-9.3467E-01	3.1806E+00	2.8195E-01	3.3150E+00		1.5511E-03	1.5356E+01	5.6351E-03	1.0383E+02
-1.3398E+00				7.4641E-01	2.9420E-01	-1.8000E+02	6.8792E-03	0.0
-1.1608E-02				8.6150E+01	1.9349E-01	0.0	1.0572E-02	-1.8000E+02

**********THE TRANSFER FUNCTIONS*****

V /D1 =	1.20000E-02	-8.18832E+00	1.47755E+01	2.15600E+01
2.7672E+00			-3.6138E-01	
6.8055E+02			-1.4694E-03	
-9.5405E-01			1.0482E+00	
PHI /D1 =	3.64770E-01	7.37555E-01	4.14680E+00	
-1.0110E+00	3.2165E+00	2.9985E-01	3.3717E+00	
R /D1 =	2.15550E-02	1.20103E-02	8.03069E-02	2.27035E-01
6.1259E-01	2.3525E+00	-2.5200E-01	2.4309E+00	
-1.7824E+00			5.6105E-01	
V /D2 =	1.00000E-03	-1.90408E+00	-2.48621E+00	5.16802E-02
-1.3253E+00			7.5456E-01	
1.9054E+03			-5.2483E-04	
2.0466E-02			-4.8862E+01	
PHI /D2 =	-1.53590E-03	1.30595E-03	1.55494E-02	
-2.7850E+00			3.5907E-01	
3.6352E+00			-2.7508E-01	
R /D2 =	3.31610E-03	4.94274E-03	1.11983E-03	8.61078E-04
-1.3821E+00			7.2352E-01	
-5.4199E-02	-4.3004E-01	1.2504E-01	4.3344E-01	

Numerator polynomials (In descending powers of s) and factors.

TABLE G-1: PARAMETER IDENTIFICATION - CONFIGURATION 1-3

********** EQUATIONS OF MOTION********

		V*	V	P*	P	PHI		R*	R	D1	D2	D3
Y	0.0	1.00E+00	1.85E-01	0.0	-1.11E+01	-3.22E+01	0.0	0.0	5.70E+02	1.50E-02	1.00E-03	0.0
L	0.0	0.0	2.06E-02	1.00E+00	2.20E+00	0.0	0.0	0.0	-1.47E+00	3.80E-01	-2.27E-03	0.0
N	0.0	0.0	-1.75E-02	0.0	6.98E-02	0.0	0.0	1.00E+00	1.91E+00	2.04E-02	4.01E-03	0.0

OUTPUT FORMAT :
THE CHARACTERISTIC EQUATION IN DESCENDING POWERS OF S

1.0000E+00 4.2891E+00 1.5241E+01 2.4327E+01 4.3590E-01

REAL	IMAGINARY	ZETA	OMEGA	TAU	PHI /V	PHI -DEG	R /V	R -DEG
-1.0030E+00	3.1006E+00	3.0780E-01	3.2588E+00		1.8514E-03	2.6073E+01	5.5030E-03	1.0525E+02
-2.2649E+00				4.4152E-01	1.1557E-01	-1.8000E+02	2.2393E-03	-1.8000E+02
-1.8123E-02				5.5179E+01	1.7239E-01	0.0	9.3755E-03	-1.8000E+02

**********THE TRANSFER FUNCTIONS*****

V /D1 = 1.50000E-02 -7.33286E+00 1.02801E+01 2.42829E+01
2.6609E+00 -3.7581E-01
4.8744E+02 -2.0515E-03
-1.2481E+00 8.0121E-01

PHI /D1 = 3.80480E-01 8.25004E-01 4.16853E+00
-1.0842E+00 3.1274E+00 3.2754E-01 3.3100E+00

R /D1 = 2.04050E-02 2.23308E-02 8.26754E-02 2.27386E-01
4.2733E-01 2.3526E+00 -1.7872E-01 2.3911E+00
-1.9490E+00 5.1307E-01

V /D2 = 1.00000E-03 -2.30912E+00 -5.17221E+00 5.07607E-02
-2.2475E+00 4.4494E-01
2.3114E+03 -4.3265E-04
9.7715E-03 -1.0234E+02

PHI /D2 = -2.26890E-03 1.13774E-03 2.48009E-02
-3.0649E+00 3.2627E-01
3.5664E+00 -2.8040E-01

R /D2 = 4.01430E-03 9.74521E-03 2.18106E-03 1.38396E-03
-2.2545E+00 4.4357E-01
-8.6584E-02 -3.8135E-01 2.2141E-01 3.9105E-01

TABLE C -2: PARAMETER IDENTIFICATION - CONFIGURATION 2-2

********** EQUATIONS OF MOTION********

		V*	V	P*	P	PHI		R*	R	D1	D2	D3
Y	0.0	1.00E+00	1.85E-01	0.0	-1.11E+01	-3.22E+01	0.0	0.0	5.70E+02	1.80E-02	1.00E-03	0.0
L	0.0	0.0	2.20E-02	1.00E+00	3.72E+00	0.0	0.0	0.0	-1.52E+00	7.42E-01	-2.44E-03	0.0
N	0.0	0.0	-1.74E-02	0.0	1.74E-02	0.0	0.0	1.00E+00	2.00E+00	3.09E-02	5.06E-03	0.0

OUTPUT FORMAT :
THE CHARACTERISTIC EQUATION IN DESCENDING POWERS OF S

1.0000E+00 5.9031E+00 1.8700E+01 3.9389E+01 5.6517E-01

REAL	IMAGINARY	ZETA	OMEGA	TAU	PHI /V	PHI -DEG	R /V	R -DEG
-3.7129E+00				2.6933E-01	7.5584E-01	-1.8000E+02	1.8345E-02	-1.8000E+02
-1.0879E+00	3.0582E+00	3.3616E-01	3.2460E+00		1.6188E-03	4.3238E+01	5.4827E-03	1.0652E+02
-1.3447E-02				6.9219E+01	1.6170E-01	0.0	8.7806E-03	-1.8000E+02

**********THE TRANSFER FUNCTIONS*****

V /D1 = 1.80000E-02 -9.24273E+00 -1.69839E+01 4.93036E+01
-3.3891E+00 2.9506E-01
5.1531E+02 -1.9406E-03
1.5684E+00 -6.3760E-01

PHI /D1 = 7.41770E-01 1.66961E+00 8.03551E+00
-1.1254E+00 3.0929E+00 3.4194E-01 3.2913E+00

R /D1 = 3.08850E-02 1.07862E-01 1.71423E-01 4.37509E-01
-3.1559E+00 3.1686E-01
-1.6822E-01 -2.1119E+00 7.9399E-02 2.1186E+00

V /D2 = 1.00000E-03 -2.90630E+00 -1.07813E+01 9.00298E-02
-3.7132E+00 2.6931E-01
2.9100E+03 -3.4364E-04
8.5318E-03 -1.2002E+02

PHI /D2 = -2.44350E-03 2.32487E-03 3.96784E-02
-3.5819E+00 2.7918E-01
4.5334E+00 -2.2059E-01

R /D2 = 5.06150E-03 1.97998E-02 4.31680E-03 2.21107E-03
-3.7139E+00 2.6926E-01
-9.8987E-02 -3.2837E-01 2.8862E-01 3.4296E-01

TABLE G -3: PARAMETER IDENTIFICATION - CONFIGURATION 3-2

********** EQUATIONS OF MOTION********

		V*	V	P*	P	PHI		R*	R	D1	D2	D3
Y	0.0	1.00E+00	1.85E-01	0.0	-1.11E+01	-3.22E+01	0.0	0.0	5.70E+02	2.20E-02	1.00E-03	0.0
L	0.0	0.0	2.20E-02	1.00E+00	6.69E+00	0.0	0.0	0.0	-1.55E+00	1.26E+00	-2.44E-03	0.0
N	0.0	0.0	-1.64E-02	0.0	-5.36E-03	0.0	0.0	1.00E+00	2.05E+00	5.61E-02	5.59E-03	0.0

OUTPUT FORMAT :
THE CHARACTERISTIC EQUATION IN DESCENDING POWERS OF S

1.0000E+00 8.9249E+00 2.4937E+01 6.5883E+01 6.3588E-01

REAL	IMAGINARY	ZETA	OMEGA	TAU	PHI /V	PHI -DEG	R /V	R -DEG
-6.6644E+00				1.5005E-01	1.8300E-01	0.0	2.1241E-03	0.0
-1.1254E+00	2.9297E+00	3.5859E-01	3.1384E+00		1.0659E-03	6.3195E+01	5.3296E-03	1.0761E+02
-9.6870E-03				1.0323E+02	1.4796E-01	0.0	8.0149E-03	-1.8000E+02

**********THE TRANSFER FUNCTIONS*****

V /D1 = 2.20000E-02 -1.77091E+01 -1.46709E+02 9.61998E+01

-8.7459E+00			1.1434E-01
8.1315E+02			-1.2298E-03
5.5094E-01			-1.8151E+00

PHI /D1 = 1.26190E+00 2.91280E+00 1.29926E+01

-1.1541E+00	2.9940E+00	3.5968E-01	3.2087E+00

R /D1 = 5.60550E-02 3.92223E-01 3.17071E-01 7.05292E-01

-6.4214E+00			1.5573E-01
-2.8787E-01	-1.3699E+00	2.0565E-01	1.3998E+00

V /D2 = 1.00000E-03 -3.20171E+00 -2.12973E+01 1.16956E-01

-6.6435E+00			1.5052E-01
3.2083E+03			-3.1169E-04
5.4871E-03			-1.8226E+02

PHI /D2 = -2.44350E-03 3.16196E-03 4.78171E-02

-3.0237E+00			2.6152E-01
5.1178E+00			-1.9540E-01

R /D2 = 5.58510E-03 3.83735E-02 7.93560E-03 2.66177E-03

-6.6683E+00			1.4996E-01
-1.0118E-01	-2.4745E-01	3.7847E-01	2.6734E-01

TABLE G-4: PARAMETER IDENTIFICATION - CONFIGURATION 5-2

********** EQUATIONS OF MOTION********

		V*	V	P*	P	PHI		R*	R	D1	D2	D3
	0.0	1.00E+00	1.20E-01	0.0	-2.15E+01	-3.20E+01	0.0	0.0	2.42E+02	1.20E-02	-8.50E-03	0.0
L	0.0	0.0	1.40E-02	1.00E+00	1.10E+00	0.0	0.0	0.0	-1.25E+00	2.01E-01	-4.36E-04	0.0
N	0.0	0.0	-7.50E-03	0.0	6.50E-02	0.0	0.0	1.00E+00	1.10E+00	1.92E-02	2.58E-03	0.0

OUTPUT FORMAT :

THE CHARACTERISTIC EQUATION IN DESCENDING POWERS OF S

1.0000E+00 2.3200E+00 3.6724E+00 2.9493E+00 1.9144E-01

REAL	IMAGINARY	ZETA	OMEGA	TAU	PHI /V	PHI -DEG	R /V	R -DEG
-5.2550E-01	1.4063E+00	3.5004E-01	1.5013E+00		5.8261E-03	2.9361E+01	5.2320E-03	1.0958E+02
-1.1981E+00				8.3466E-01	9.8746E-02	-1.8000E+02	1.8860E-03	-1.8000E+02
-7.0899E-02				1.4105E+01	6.1700E-02	0.0	7.5690E-03	-1.8000E+02

**********THE TRANSFER FUNCTIONS*****

V /D1 =	1.20000E-02	-3.12092E-01	9.74522E+00	7.83880E+00
1.3396E+01	2.5567E+01	-4.6411E-01	2.8864E+01	
-7.8409E-01				1.2754E+00

PHI /D1 =	2.00710E-01	2.68697E-01	4.58971E-01
-6.5937E-01	1.3560E+00	4.4265E-01	1.5122E+00

R /D1 =	1.91990E-02	1.04667E-02	3.91864E-02	5.68226E-02
2.8221E-01	1.6086E+00	-1.7280E-01	1.6332E+00	
-1.1096E+00				9.0123E-01

V /D2 =	-8.50000E-03	-6.53571E-01	-6.60830E-01	8.80308E-02
-1.1457E+00				8.7280E-01
-7.5864E+01				1.3181E-02
1.1915E-01				-8.3928E+00

PHI /D2 =	-4.36330E-04	2.81524E-03	8.32159E-03
-2.2034E+00			4.5384E-01
8.6555E+00			-1.1553E-01

R /D2 =	2.58310E-03	3.11595E-03	9.70773E-04	1.05017E-03
-1.1798E+00				8.4759E-01
-1.3234E-02	-5.8687E-01	2.2545E-02	5.8702E-01	

TABLE G-5: PARAMETER IDENTIFICATION - CONFIGURATION L1-2

********** EQUATIONS OF MOTION********

		V*	V	P*	P	PHI		R*	R	D1	D2	D3
Y	0.0	1.00E+00	1.20E-01	0.0	-2.15E+01	-3.20E+01	0.0	0.0	2.42E+02	1.20E-02	-8.50E-03	0.0
L	0.0	0.0	1.40E-02	1.00E+00	2.25E+00	0.0	0.0	0.0	-1.26E+00	2.01E-01	-4.36E-04	0.0
N	.0	0.0	-7.50E-03	0.0	3.00E-02	0.0	0.0	1.00E+00	1.00E+00	2.09E-02	2.58E-03	0.0

OUTPUT FORMAT :
THE CHARACTERISTIC EQUATION IN DESCENDING POWERS OF S

1.0000E+00 3.3700E+00 4.7947E+00 5.0105E+00 1.4673E-01

REAL	IMAGINARY	ZETA	OMEGA	TAU	PHI /V	PHI -DEG	R /V	R -DEG
-2.2129E+00				4.5189E-01	1.5977E+00	0.0	9.3641E-02	0.0
-5.5346E-01	1.3721E+00	3.7986E-01	1.4833E+00		4.2042E-03	5.6565E+01	5.3396E-03	1.0738E+02
-3.0135E-02				3.3184E+01	6.3037E-02	0.0	7.7969E-03	-1.8000E+02

**********THE TRANSFER FUNCTIONS*****

V /D1 =	1.20000E-02	-7.22045E-01	1.37472E+00	7.26590E+00
4.4827E+00				-2.2308E-01
5.8016E+01				-1.7237E-02
-2.3282E+00				4.2952E-01

PHI /D1 =	2.00710E-01	2.50808E-01	4.62741E-01	
-6.2480E-01	1.3839E+00	4.1149E-01	1.5184E+00	

R /D1 =	2.09440E-02	4.37060E-02	4.37710E-02	5.76029E-02
-1.7306E+00				5.6162E-01
-1.5312E-01	-1.2334E+00	1.2320E-01	1.2428E+00	

V /D2 =	-8.50000E-03	-6.62496E-01	-1.38399E+00	8.94281E-02
-2.2129E+00				4.5190E-01
-7.5791E+01				1.3194E-02
6.2731E-02				-1.5941E+01

PHI /D2 =	-4.36330E-04	2.85887E-03	8.31496E-03	
-2.2819E+00				4.5832E-01
8.7340E+00				-1.1450E-01

R /D2 =	2.58310E-03	6.07124E-03	1.25620E-03	1.05017E-03
2.2136E+00				4.5174E-01
-6.3762E-02	-4.2306E-01	1.5952E-01	4.2855E-01	

TABLE G-6: PARAMETER IDENTIFICATION - CONFIGURATION L2-1

********** EQUATIONS OF MOTION********

		V*	V	P*	P	PHI		R*	R	D1	D2	D3
Y	0.0	1.00E+00	1.20E-01	0.0	-2.15E+01	-3.20E+01	0.0	0.0	2.42E+02	1.20E-02	-8.50E-03	0.0
L	0.0	0.0	1.40E-02	1.00E+00	3.83E+00	0.0	0.0	0.0	-1.25E+00	3.07E-01	-4.36E-04	0.0
N	0.0	0.0	-7.50E-03	0.0	2.50E-02	0.0	0.0	1.00E+00	1.00E+00	2.97E-02	2.58E-03	0.0

OUTPUT FORMAT :

THE CHARACTERISTIC EQUATION IN DESCENDING POWERS OF S

1.0000E+00 4.9500E+00 6.5580E+00 8.0538E+00 1.4673E-01

REAL	IMAGINARY	ZETA	OMEGA	TAU	PHI /V	PHI -DEG	R /V	R -DEG
-3.7752E+00				2.6488E-01	1.0559E-01	0.0	6.2955E-03	0.0
-5.7814E-01	1.3294E+00	3.9880E-01	1.4497E+00		2.6603E-03	7.2881E+01	5.4495E-03	1.0769E+02
-1.3493E-02				5.4073E+01	6.1977E-02	0.0	7.6755E-03	-1.8000E+02

**********THE TRANSFER FUNCTIONS*****

V /D1 =

1.20000E-02	-6.29725E-01	-8.38127E+00	1.10248E+01
-1.7346E+01			7.4927E-02
5.6267E+01			-1.7773E-02
1.2234E+00			-8.1737E-01

PHI /D1 =

3.07180E-01	3.80963E-01	6.99824E-01	
-6.2010E-01	1.3761E+00	4.1083E-01	1.5094E+00

R /D1 =

2.96710E-02	1.09611E-01	7.14731E-02	8.70937E-02
-3.2298E+00			3.0962E-01
-2.3222E-01	-9.2461E-01	2.4359E-01	9.5333E-01

V /D2 =

-8.50000E-03	-6.75926E-01	-2.38513E+00	8.94281E-02
-3.7399E+00			2.6738E-01
-7.5818E+01			1.3189E-02
3.7104E-02			-2.6951E+01

PHI /D2 =

-4.36330E-04	2.86887E-03	8.31496E-03	
-2.7819E+00			4.5832E-01
8.7340E+00			-1.1450E-01

R /D2 =

2.58310E-03	1.01504E-02	1.64550E-03	1.05017E-03
-3.7697E+00			2.6387E-01
-6.9892E-02	-3.1999E-01	2.1339E-01	3.2753E-01

TABLE G -7: PARAMETER IDENTIFICATION - CONFIGURATION L3-1

********** EQUATIONS OF MOTION********

		V*	V	P*	P	PHI		R*	R	D1	D2	D3
Y	0.0	1.00E+00	1.20E-01	0.0	-2.15E+01	-3.20E+01	0.0	0.0	2.42E+02	1.20E-02	-8.50E-03	0.0
L	0.0	0.0	1.40E-02	1.00E+00	4.87E+00	0.0	0.0	0.0	-1.25E+00	3.80E-01	-4.36E-04	0.0
N	0.0	0.0	-7.50E-03	0.0	1.50E-02	0.0	0.0	1.00E+00	1.00E+00	2.97E-02	2.58E-03	0.0

OUTPUT FORMAT :
THE CHARACTERISTIC EQUATION IN DESCENDING POWERS OF S

1.0000E+00 5.9900E+00 7.7103E+00 1.0033E+01 1.4673E-01

REAL	IMAGINARY	ZETA	OMEGA	TAU	PHI /V	PHI -DEG	R /V	R -DEG
-4.8211E+00				2.0742E-01	7.7342E-02	0.0	3.4280E-03	0.0
-5.7707E-01	1.3133E+00	4.0229E-01	1.4345E+00		2.1005E-03	7.8025E+01	5.4715E-03	1.0792E+02
-1.4790E-02				6.7611E+01	6.1602E-02	0.0	7.6314E-03	-1.8000E+02

**********THE TRANSFER FUNCTIONS*****

V /D1 = 1.20000E-02 1.05699E+00 -1.23972E+01 1.33722E+01
9.3811E+00 -1.0660E-01
-9.8667E+01 1.0135E-02
1.2039E+00 -8.3063E-01

PHI /D1 = 3.80480E-01 4.63059E-01 8.41829E-01
-6.0852E-01 1.3573E+00 4.0910E-01 1.4875E+00

R /D1 = 2.96710E-02 1.42441E-01 8.73192E-02 1.04710E-01
-4.3077E+00 2.3214E-01
-2.4650E-01 -8.7091E-01 2.7234E-01 9.0512E-01

V /D2 = -8.50000E-03 -6.84766E-01 -3.04332E+00 8.94281E-02
-4.7521E+00 2.1043E-01
-7.5838E+01 1.3186E-02
2.9193E-02 -3.4265E+01

PHI /D2 = -4.36330E-04 2.85887E-03 8.31496E-03
-2.1819E+00 4.5832E-01
8.7340E+00 -1.1450E-01

R /D2 = 2.58310E-03 1.20324E-02 1.90219E-03 1.05017E-03
-4.6329E+00 2.0692E-01
-6.7493E-02 -2.8208E-01 2.3267E-01 2.9004E-01

TABLE G -8: PARAMETER IDENTIFICATION - CONFIGURATION L4-1

due to inertia changes of the NT-33A as outlined in Appendix I. The simulated aircraft characteristics were estimated to change by approximately 5-8% with the NT-33A inertia changes despite the fuel remaining gain schedules.

- Fast Fourier Transformation Analysis:

The technique of Fast Fourier Transformation was applied to flight time history data. This transformation technique converts time domain information into frequency domain response characteristics. Fast Fourier Transformations were used to provide an alternate identification method to the previously described time domain methods. The data and results of this work are presented in Appendix H.

The identification of the lateral augmented aircraft dynamics was generally in very close agreement. The "answers" provided by each method were referenced to quote nominal augmented aircraft dynamics; hence, the configuration characteristics are stated with good accuracy (within 10% of the configuration dynamics that were actually evaluated) and good confidence. This is particularly true when one considers the wide variety of identification techniques employed and the checking process provided by the calibration data taken after evaluations which ensured that the configurations were indeed simulated correctly.

Control System Dynamics:

The roll flight control system dynamics of this experiment consisted of three elements: prefilters, time delays, and nonlinear shaping networks. None of these elements were introduced into the yaw control system. The control system dynamic elements are placed on line for the simulation by switches in the rear, safety pilot cockpit of the NT-33A. The placement of the roll dynamic elements in the experiment flight control system is shown in Figure 2-1.

1. Roll Prefilters:

The roll prefilters are created by proper design of analog electronic circuitry. First order lead/lag and lag networks were used in this simulation. These elements were calibrated and checked on the ground by step and frequency response measures. Whenever possible, these calibrations were verified in flight during the evaluation flying phase. Because of noise propagation problems in the NT-33A roll control system with the force command system, filtering was needed at all times during the experiment. The nominal filter was a first-order prefilter with a 40 rad/sec breakpoint.

For several evaluations which required either high command or feedback gains, a variable stability system instability developed despite the nominal filtering. The system instability manifested itself as a very high frequency aileron flutter ($\approx$ *30 rad/sec*) characterized as aileron "buzz". Aileron buzz compromised the simulation fidelity by masking the configuration characteristics. Consequently, these evaluations were considered invalid and rejected from the experiment data base (Appendix B). Aileron buzz was also a problem in the

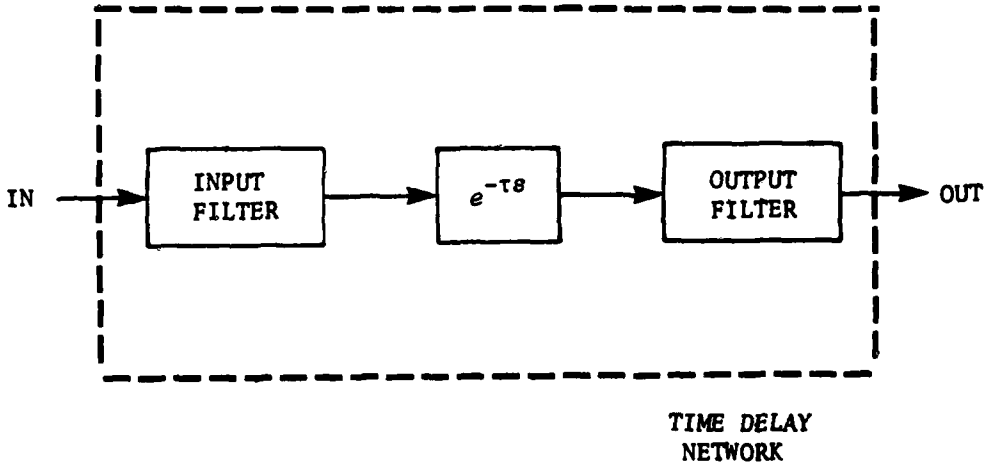
evaluation of the special lag/lead and lead/lag filters (filters F6 and F7). To eliminate this problem, the lag filtering inherent to the time delay circuit was incorporated. This procedure solved the VSS instability problems for these evaluations but unfortunately negated the evaluation of filters F6 and F7 without the addition of time delay. The filters in the time delay circuit are described in the next subsection.

2. Time Delay Network:

As shown in the experiment results, the introduction of time delay into a configuration control system can drastically degrade lateral flying qualities. Although values of equivalent time delay have been specified according to each configuration identifier, a precise definition of the time delay network is presented to allow correct interpretation of its effects and avoid confusion over semantics (e.g. "equivalent" vs. "pure" time delay). The stated values of equivalent time delay for each identifier are the amount of equivalent delay added to the roll control system. Additional analysis must be performed to determine the total delay of a particular configuration.

The time delay circuit of the NT-33A is, by itself, a pure time delay which merely "holds" the input signal a finite period of time before it is output. This circuit is a digital system producing a pure time delay which does not affect the amplitude content of the signal in any way. However, this time delay circuit is surrounded by two low pass analog filters in the fly-by-wire NT-33A control system for the suppression of noise and signal smoothing (Figure G-2). The two analog filters are third-order Butterworth filters with break frequencies of 50 cycles per second and 50 radians per second for the input and output filters, respectively.

Table G-9 documents the pure delay due to the time delay circuit for a given configuration identifier; remembering, of course, that associated with this "pure" time delay are two analog filters which are activated when time delay is selected. Equivalent time delay measures were derived by the frequency domain matching technique of the McDonnell-Douglas Corporation ("McFit"). By this method, the analog filters are shown to contribute a constant delay of about 43 msec. A time domain equivalent systems technique was used in Section 6 to derive "effective" roll mode and time delay parameters which proved to correlate well with lateral flying qualities. Nearly identical values of time delay for the time delay circuit are measured by both the frequency domain (McFit) and time domain equivalent methods in the context of this experiment. However, important differences pertain between the two equivalent systems methods; therefore, the measured equivalent parameters and corresponding flying qualities "answers" are neither identical nor interchangeable. Close regard must be made concerning the technique used to derive "equivalent" parameters. The distinction has been made in this report by the use of the modifier "equivalent" for the "McFit" method and "effective" for the time domain technique.



INPUT FILTER:

$$\frac{1}{\left(\frac{s}{314}+1\right)\left[\frac{s^2}{314^2}+\frac{2(0.5)}{314}\,s+1\right]}$$

OUTPUT FILTER:

$$\frac{1}{\left(\frac{s}{50}+1\right)\left[\frac{s^2}{50^2}+\frac{2(0.5)}{50}\,s+1\right]}$$

Figure G-2: NT-33A TIME DELAY NETWORK

TABLE G-9: SIMULATED TIME DELAY

Time Delay Identifier	Pure Digital Delay, τ	Equivalent Time Delay, τ_E
T0	10 ms	55 ms
T1	30 ms	75 ms
T2	60 ms	105 ms
T3	80 ms	125 ms
T4	180 ms	225 ms

3. Nonlinear Command Gradients:

Four nonlinear command gradients were investigated in this program. Each gradient was created by the appropriate analog circuits and located in the roll control system prior to the prefilter and time delay circuits (Figure 2-1).

The first nonlinear gradient was selected based on the work of Reference 20 with the DIGITAC aircraft. This gradient was judged during pilot evaluations as being the best command shaping network tested in that program.

The equation for this gradient is written (for positive pilot inputs):

$$\bullet \text{ N1: (DIGITAC) } F_{AS_{OUT}} = \begin{cases} (0.16)F_{AS_{IN}}^2, & \text{for } F_{AS_{IN}} \leq 3.5; \\ (1.1077)F_{AS_{IN}} - 1.94, & \text{for } F_{AS_{IN}} > 3.5. \end{cases}$$

The three remaining nonlinear gradients evaluated were formed by two breakpoints creating a three linear segment command gradient. The gradients were designed under the philosophy that, when flown with a particular steady state roll rate per unit stick force ($|p/F_{AS}|_{SS}$) configuration, the breakpoints occur as 3 deg/sec and 15 deg/sec roll rates are attained. This design philosophy was not modelled after any design in a particular aircraft. The gradients were selected to provide three gradients for evaluation which varied in some systematic manner.

The three gradients are (for positive pilot inputs):

- N2:
$$F_{AS_{OUT}} = \begin{cases} (0.2)F_{AS_{IN}} & , \text{ for } F_{AS_{IN}} \leq 0.6 \\ (0.65)F_{AS_{IN}} - 0.27 & , \text{ for } 0.6 < F_{AS_{IN}} \leq 1.34 \\ F_{AS_{IN}} - 0.74 & , \text{ for } F_{AS_{IN}} > 1.34 \end{cases}$$

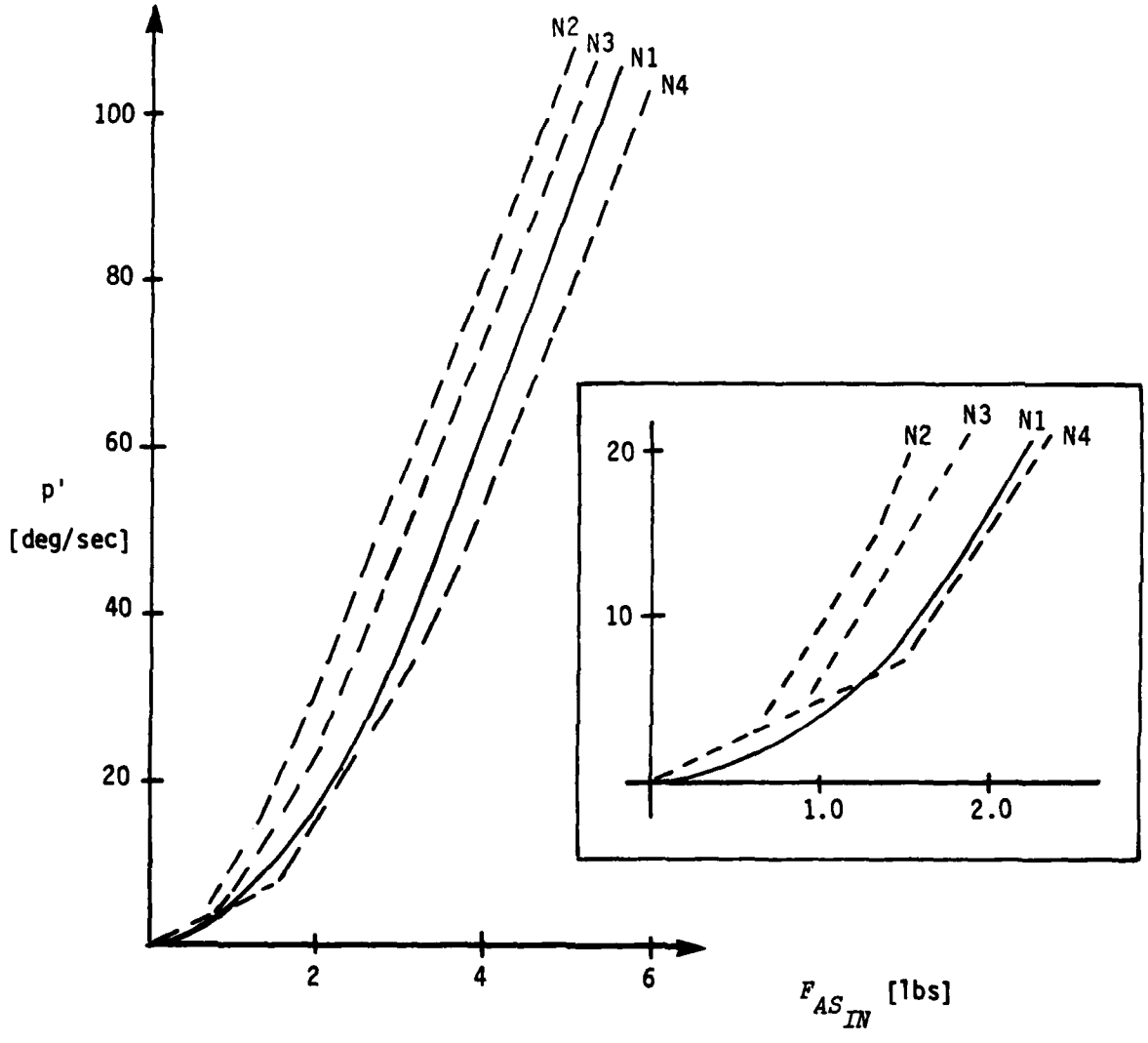
- N3:
$$F_{AS_{OUT}} = \begin{cases} (0.2)F_{AS_{IN}} & , \text{ for } F_{AS_{IN}} \leq 0.83 \\ (0.65)F_{AS_{IN}} - 0.37 & , \text{ for } 0.83 < F_{AS_{IN}} \leq 1.86 \\ F_{AS_{IN}} - 1.03 & , \text{ for } F_{AS_{IN}} > 1.86 \end{cases}$$

- N4:
$$F_{AS_{OUT}} = \begin{cases} (0.2)F_{AS_{IN}} & , \text{ for } F_{AS_{IN}} \leq 1.5 \\ (0.65)F_{AS_{IN}} - 0.68 & , \text{ for } 1.5 < F_{AS_{IN}} \leq 3.35 \\ F_{AS_{IN}} - 1.85 & , \text{ for } F_{AS_{IN}} > 3.35 \end{cases}$$

The prescribed breakpoint design phisosophy was met when N2 was flown with a nominal 25 deg/sec/lb configuration, N3 with an 18 deg/sec/lb case, and, finally, N4 with a 10 deg/sec/lb configuration. Not all of the evaluations with these gradients were performed in this manner. These cases, nevertheless, are valid data points. To illustrate the differences between these four gradients, the command roll rate for a 25 deg/sec/lb roll rate configuration (-4 series) with each of the four gradients is plotted as a function of pilot stick force ($F_{AS_{IN}}$) (Figure G-3).

Roll And Yaw Feel System And Actuator Characteristics:

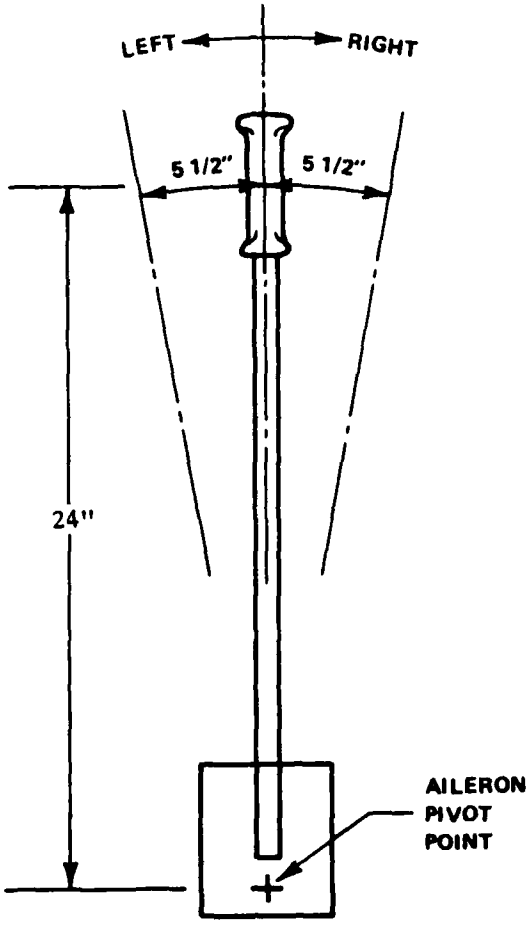
For this experiment, a standard centerstick and rudder pedal arrangement was used for aircraft roll and yaw control. The physical dimensions of these controllers are illustrated in Figure G-4. A simulated linear spring force gradient was mechanized in the centerstick and rudder pedal feel systems



p' Commanded steady state roll rate for 25°/sec/lb configuration

Figure G-3: LATHOS NONLINEAR GRADIENTS

AILERON STICK DIMENSIONS AND TRAVEL:



RUDDER PEDAL DIMENSIONS AND TRAVEL:

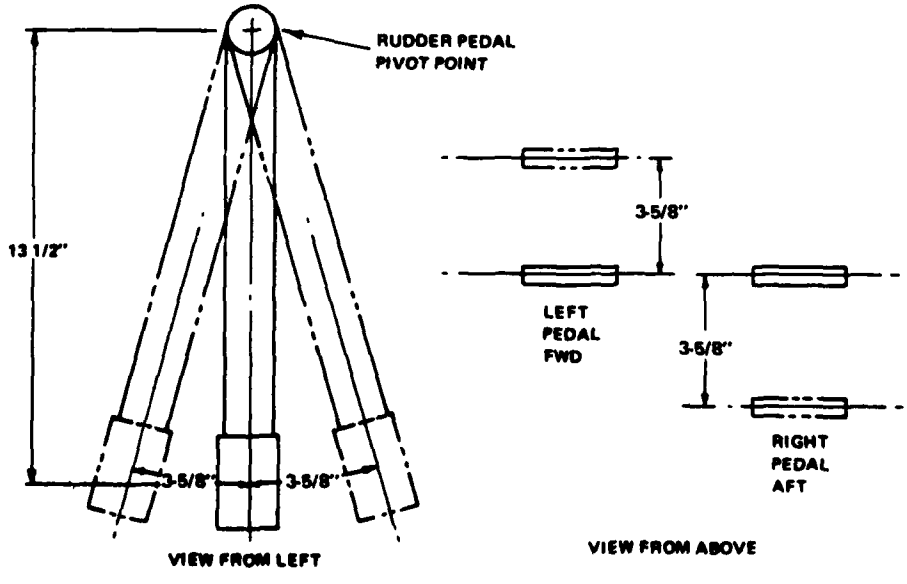


Figure G-4: AILERON STICK AND RUDDER PEDAL GEOMETRIES

and held constant throughout the program. The values were chosen to approximate closely the spring force gradients of other high performance fighter aircraft, but more importantly, the stick force per deflection gradients were tailored to levels which were not objectionable to the evaluation pilots. Although available, essentially no friction or breakout forces were included in either controller.

The lateral centerstick feel system characteristics were held fixed for both flight phase experiment tasks. The lateral feel system dynamics were selected to be sufficiently fast and not a factor in the experiment.

The lateral feel system transfer function is:

$$\frac{\delta_{AS}}{F_{AS}} = \frac{0.29}{\left(\frac{s}{25}\right)^2 + \frac{2(0.7)}{25}\, s + 1} \qquad (in/lb)$$

The aileron actuator transfer function is described by a second order system possessing the characteristics:

$$\omega_a = 60 \text{ rad/sec}$$

$$\zeta_a = 0.7$$

Command signals to the aileron actuator are first passed through a 200 radian per second, first order lag prefilter for smoothing.

Two values of rudder feel system spring force gradient were simulated for the different experiment flight phase tasks. For the up and away, Flight Phase Category A tasks, the spring force gradient was 100 lb/inch. The gradient was reduced to 80 lb/inch in the landing and approach task. This change was necessary since little rudder usage was needed for the target tracking or aerial refueling task; whereas, crosswinds during the landing task required rudder compensation and the lower pedal force gradient was preferred.

The rudder pedal feel system transfer functions for the flight phase Category A and C tasks are, respectively:

Flight Phase Category A: $$\frac{\delta_{RP}}{F_{RP}} = \frac{0.01}{\left(\frac{s}{30}\right)^2 + \frac{2(0.6)}{30}\, s+1} \qquad (in/lb)$$

Flight Phase Category C: $\frac{\delta_{RP}}{F_{RP}} = \frac{0.0125}{(\frac{s}{30})^2 + \frac{2(0.6)}{30} s+1}$ *(in/lb)*

The rudder actuator transfer function for both tasks is described by a second order system possessing the characteristics:

$$\omega_r = 60 \text{ rad/sec}$$

$$\zeta_r = 0.7$$

Signals to the rudder actuator are filtered by a first-order 200 rad/sec lag prefilter.

Longitudinal Configuration Characteristics:

Extensive calibrations of the longitudinal configurations were not undertaken since this experiment was centered on lateral-directional flying qualities. However, the longitudinal configurations were tailored to give excellent longitudinal flying qualities; the absence of adverse pilot commentary concerning longitudinal flying qualities verifies achievement of this goal.

1. Augmented Aircraft Longitudinal Configurations:

The longitudinal dynamics were attained by feeding back pitch rate and angle of attack to the NT-33A elevator actuator through the variable stability system. Essentially Level 1 short period and phugoid dynamics for both flight phase categories resulted. The longitudinal command gains, $M_{F_{ES}}$ were determined during the calibration flying phase based on evaluation pilot commentary. Reasonable stick force per g levels were achieved and the command gains remained constant for the remainder of the experiment. Table G-10 summarizes the simulated longitudinal augmented aircraft dynamics. Note that the Flight Phase Category C dynamics are separated into the approach and flare flight condition. Nominal approach airspeed was 135 KIAS and the typical airspeed at touchdown was 120 KIAS. All approaches are flown on the front side of the power-required versus velocity curve.

2. Pitch Feel System and Actuator Characteristics:

The feel system characteristics were set at values which, from past programs, have been acceptable. No adverse pilot comments were directed toward the spring force gradient levels in pitch. The physical dimensions of the pitch controller are shown in Figure G-5. The feel system transfer function for the force command, pitch control system in both flight phase tasks is:

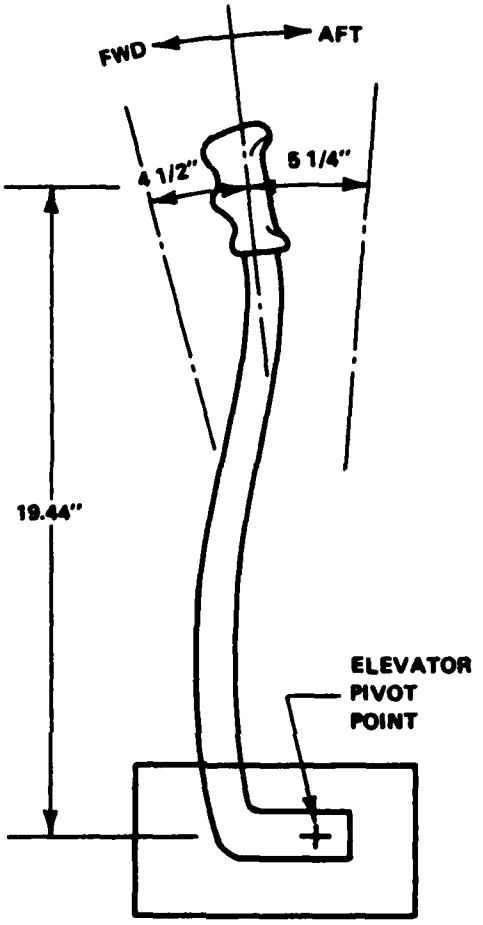


Figure G-5: ELEVATOR STICK DIMENSIONS AND TRAVEL

TABLE G-10

SIMULATED LONGITUDINAL AUGMENTED AIRCRAFT CHARACTERISTICS

	Flight Phase Category A	Flight Phase Category C	
		Flare	Approach
$\omega_{n_{sp}}$	5.6 rad/sec	2.3 rad/sec	2.6 rad/sec
ζ_{sp}	0.7	0.6	0.6
$1/\tau_{\theta_2}$	0.6 sec	1.4 sec.	1.25 sec
n/α	29 g/rad	4.5 g/rad	5.6 g/rad
ω_{n_p}	0.1 rad/sec	0.17 rad/sec	0.15 rad/sec
ζ_p	0.07	0.15	0.11
F_{es}/g	6 lb/g	21 lb/g	25 lb/g

$$\frac{\delta_{ES}}{F_{ES}} = \frac{0.143}{\left(\frac{s}{26}\right)^2 + \frac{2(0.6)}{26}s + 1} \quad (in/lb)$$

Essentially no breakout or friction forces were present in the longitudinal center stick.

The elevator actuator transfer function is:

$$\frac{\delta_E}{\delta_{E_c}} = \frac{1}{\left(\frac{s}{75}\right)^2 + \frac{2(0.7)}{75}s + 1} \quad (deg/deg)$$

Signals to the elevator actuator are passed through a 200 radian per second, first-order lag prefilter for smoothing.

3. Control System Dynamics:

No time delay or nonlinear command shaping elements were introduced into the pitch command path for this experiment. However, a pitch prefilter was incorporated for filtering in the force command system. A first-order lag prefilter having a break frequency of 80 rad/sec was used for each evaluation.

APPENDIX H

FAST FOURIER TRANSFORMATION ANALYSIS

The technique of Fast Fourier Transformation (FFT) was applied to appropriate flight data. This analysis was initiated as an additional method for identification of the lateral (roll) configuration characteristics. The results and analyses of the data transformation are described in this appendix.

Background:

The Fast Fourier Transformation technique extracts frequency response characteristics from time history data. By plotting the transformation results in the form of Bode plots, transfer functions can be derived and/or identified.

The Fourier transformation of time response data is subject to several assumptions (Reference 21) which determine the uniqueness of the transformation. Further, the quality of the Fast Fourier Transformation is primarily dependent upon the output (response) parameter(s) being sufficiently perturbed by the input over a suitably large frequency range. Hence, the quality of the transformation results depends upon the inputs used to generate the data and the resulting data scatter reflects both the quality and uniqueness of the transformation. Correlation coefficients, unlike power spectral analyses, are not computed. The "weighting" that the analyst may correctly apply to the results is, therefore, a function of the data scatter. To ensure good transformation results, variable frequency, sine-wave-type inputs (frequency sweeps) are used to perturb the aircraft.

Data:

As part of this analysis, several data flights were attempted after the evaluation flying phase to generate response data using the frequency sweep pilot inputs. Unfortunately, these flights were less than successful due to mechanical and variable stability system problems with the NT-33A aircraft (Reference 22). Only three records of data were obtained using frequency sweep inputs:

1) Configuration 2-2 (Flight 2703)
2) Configuration 1-3 (Flight 2769)
3) Ground Record

The ground record was taken to identify the frequency response characteristics of the roll flight control system dynamic elements via FFT's (δ_A/F_{AS} transfer function).

With only three records of data available from the special flights, alternative data sources were explored. Although this data were not ideal for application of Fast Fourier Transformations, it were generally suitable. The quality of the transformation results, as stated earlier, is gauged by the scatter of the resulting transformation. The flight data transformed used was:

4) Configuration 2-3 (Flight 2491)
5) Configuration 2-4 (Flight 2498)
6) Configuration 3-3 (Flight 2497)
7) Configuration 5-2 (Flight 2470)

None of the power approach configurations have been analyzed to date using FFT's.

Results:

The seven records of data were applied to the Fast Fourier Transformation technique to derive each configuration's P/F_{AS} frequency response. The responses are presented on Bode plots. For comparison purposes, the FFT results are overplotted with the frequency responses of each configuration as described by their nominal dynamics (Appendix G). The circular symbol (O) and the triangular symbol (Δ) represent the magnitude and phase determined through the FFT, respectively (Figures H-1 through H-6).

As the figures suggest, the frequency response characteristics determined from the Fourier Transformation agree quite well with the nominal configuration characteristics (as one would expect). No extraneous or previously undetected dynamic modes are reflected in the FFT results.

Some data scatter is noted in the frequency responses derived from flight data which were not generated by frequency sweep pilot inputs (Figures H-3 to H-6). This scatter reflects the inadequacy of non-tailored pilot inputs for this type of analysis, rather than any dynamics in the configuration's P/F_{AS} transfer functions. Conversely, the merits of frequency sweep inputs are illustrated by the extremely smooth variation of the transformation results with frequency in Figures H-1 and H-2.

It is appropriate to note that the frequency responses shown in the previous Bode plots are not of the actual P/F_{AS} transfer functions. The responses include the additional dynamics of the NT-33 recording system. Any measurements taken from these plots would, therefore, be inaccurate. The configuration characteristics presented in Appendix G should be used to produce the correct configuration frequency responses, if desired.

Finally, the transformation results obtained from the ground record data are shown in Figure H-7 with the frequency response of the nominal roll flight control system dynamics as given in Appendix G (δ_A/F_{AS} transfer function). The circular symbol (O) and triangular symbol (Δ) represent the magnitude and phase of the transfer function determined by the FFT, respectively. The frequency response obtained via FFT's is essentially identical to the frequency response derived from the nominal roll control system dynamics.

Conclusion:

The results of this data analysis show that frequency responses of the LATHOS configurations derived through the FFT, were essentially identical to the Bode plots of the nominal configuration characteristics. The FFT results substantiate further the configuration description and identification performed in this program.

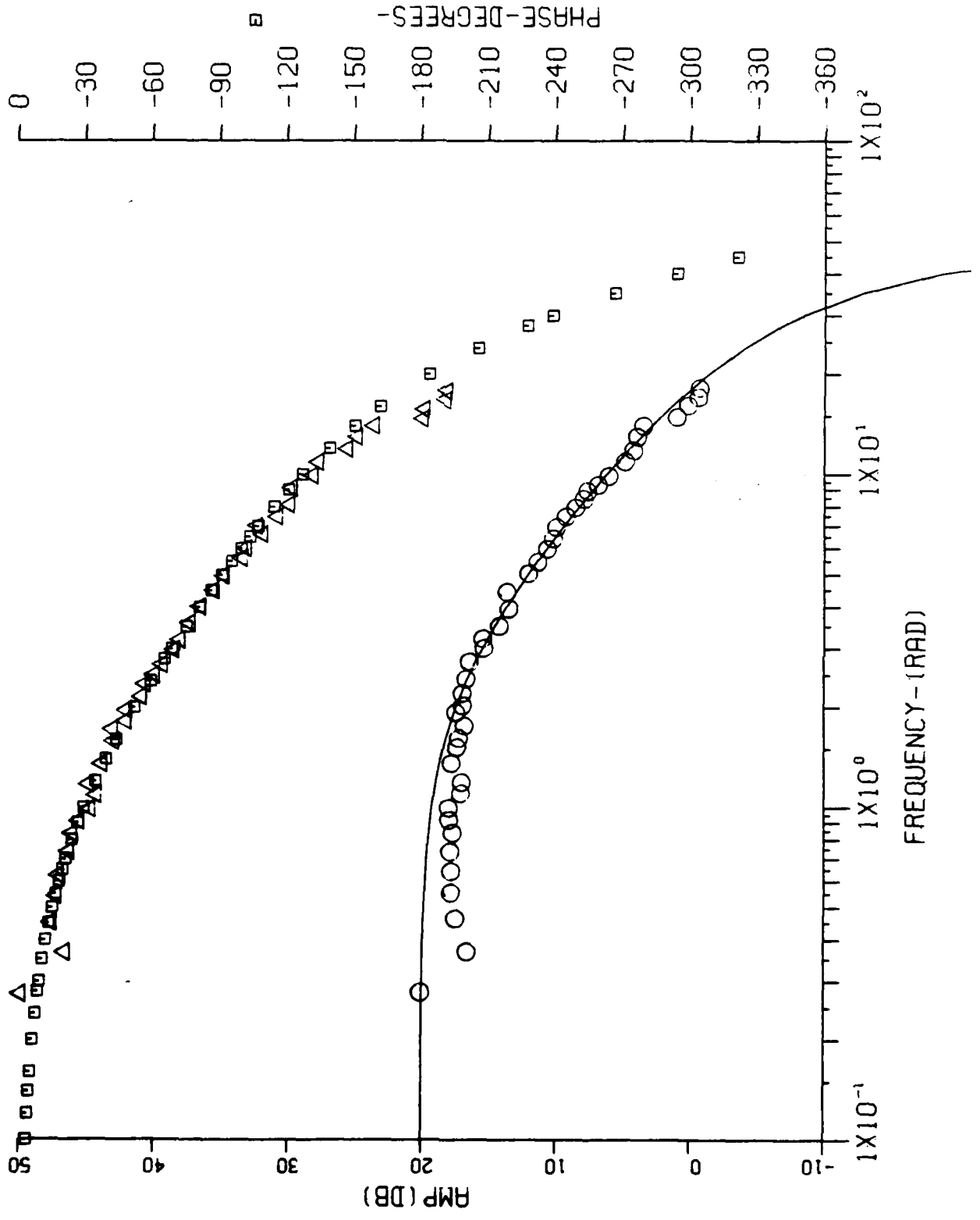


Figure H-1: LATHOS CONFIGURATION 2-2

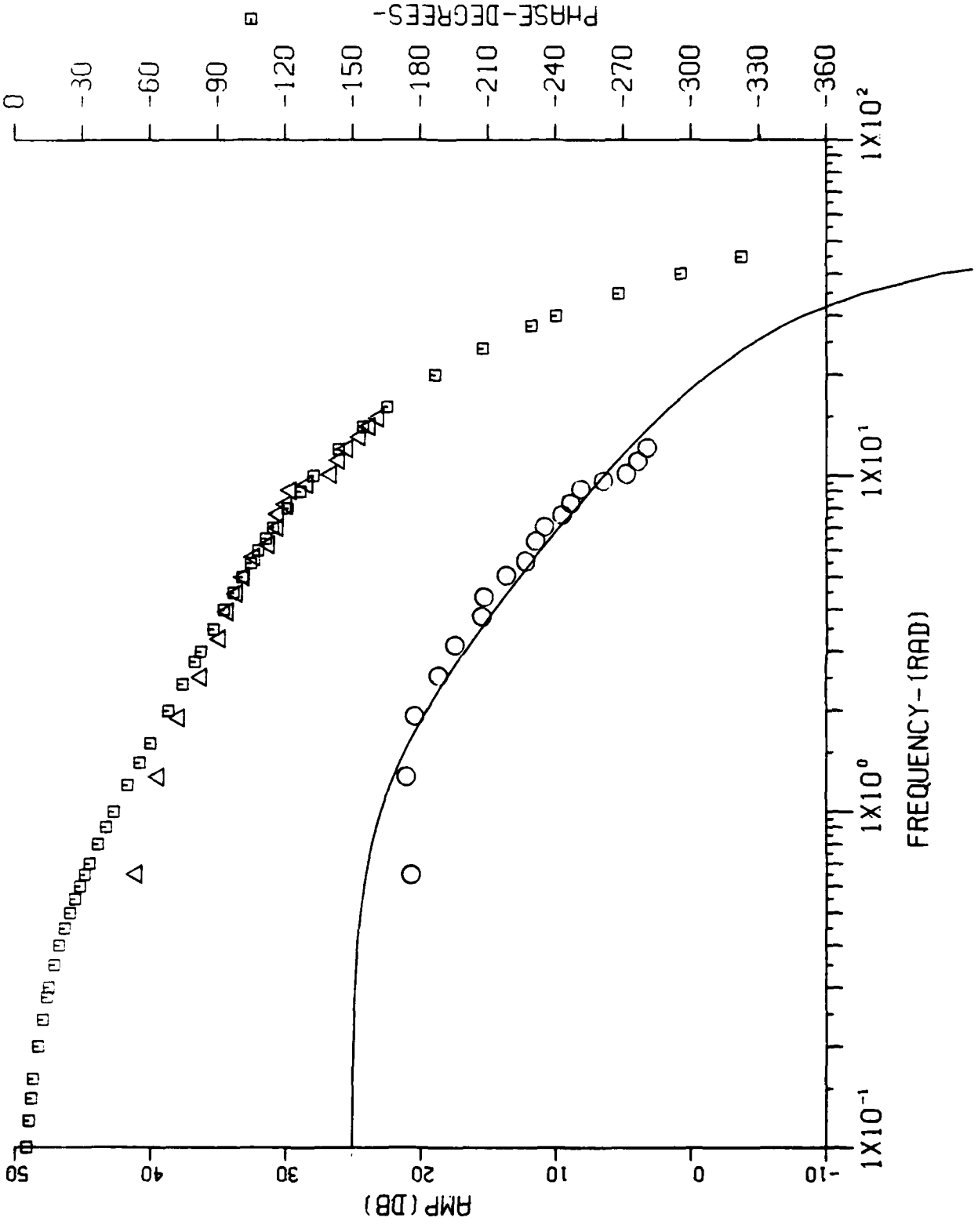


Figure H-2: LATHOS CONFIGURATION 1-3

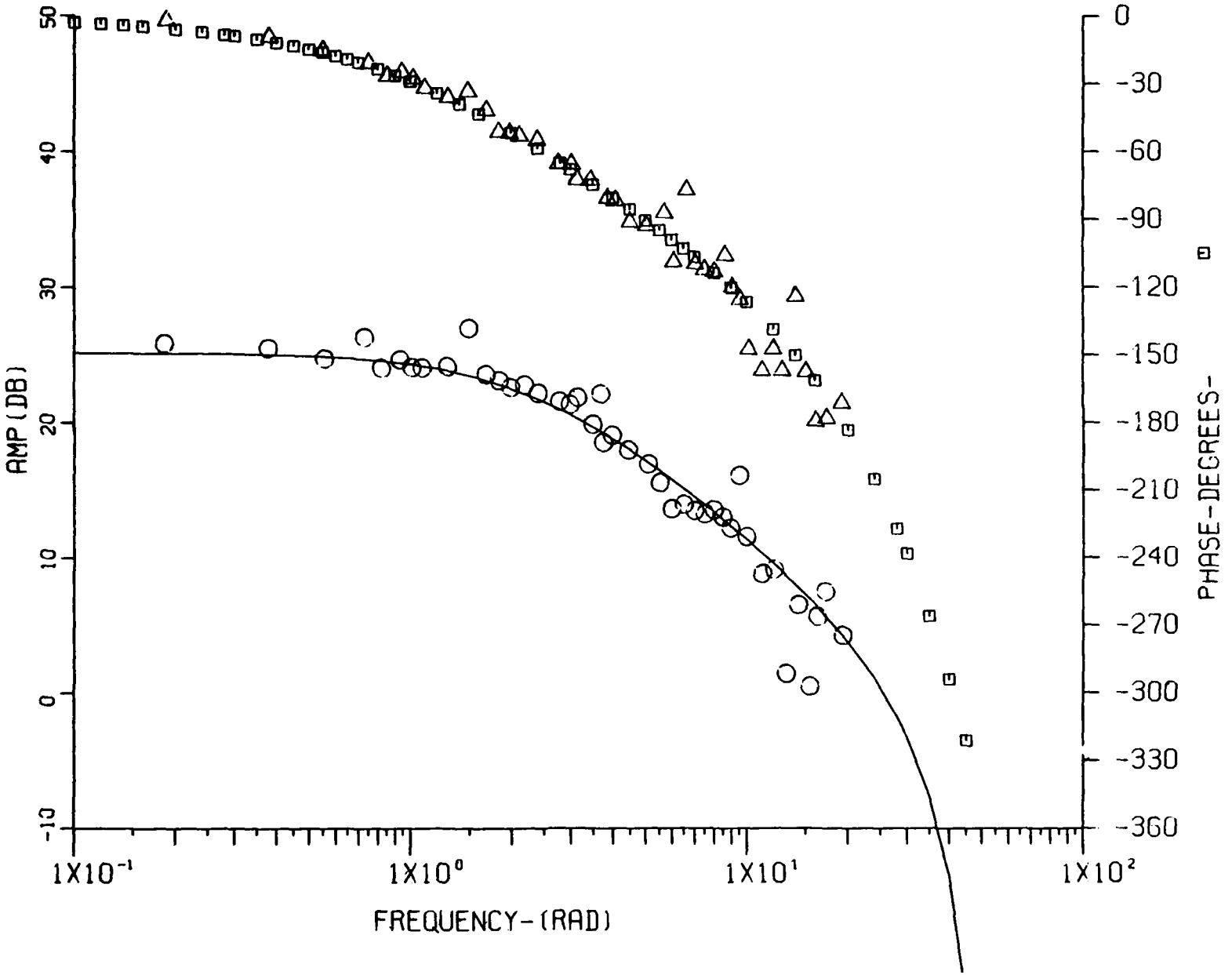


Figure H-3: LATHOS CONFIGURATION 2-3

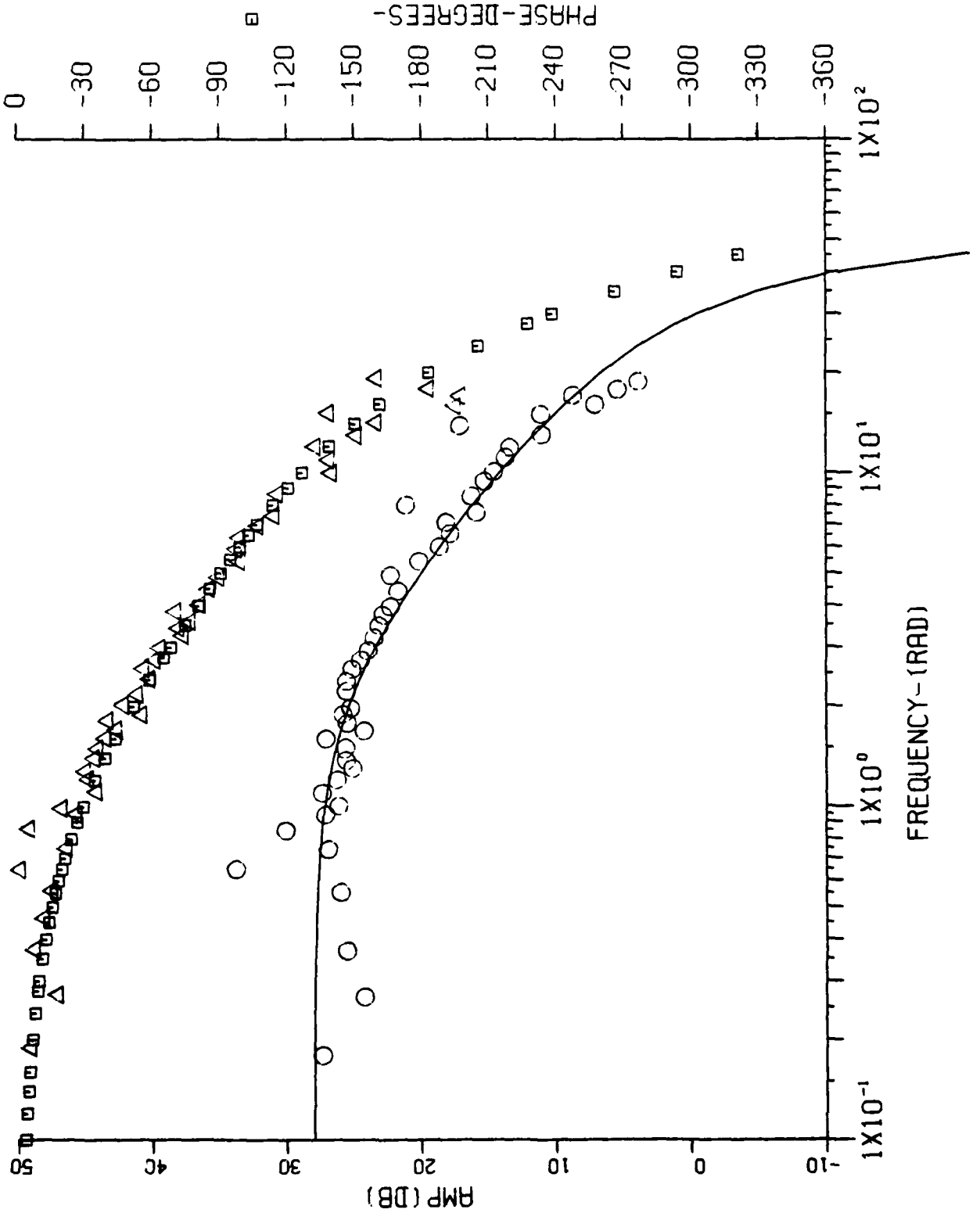


Figure H-4: LATHOS CONFIGURATION 2-4

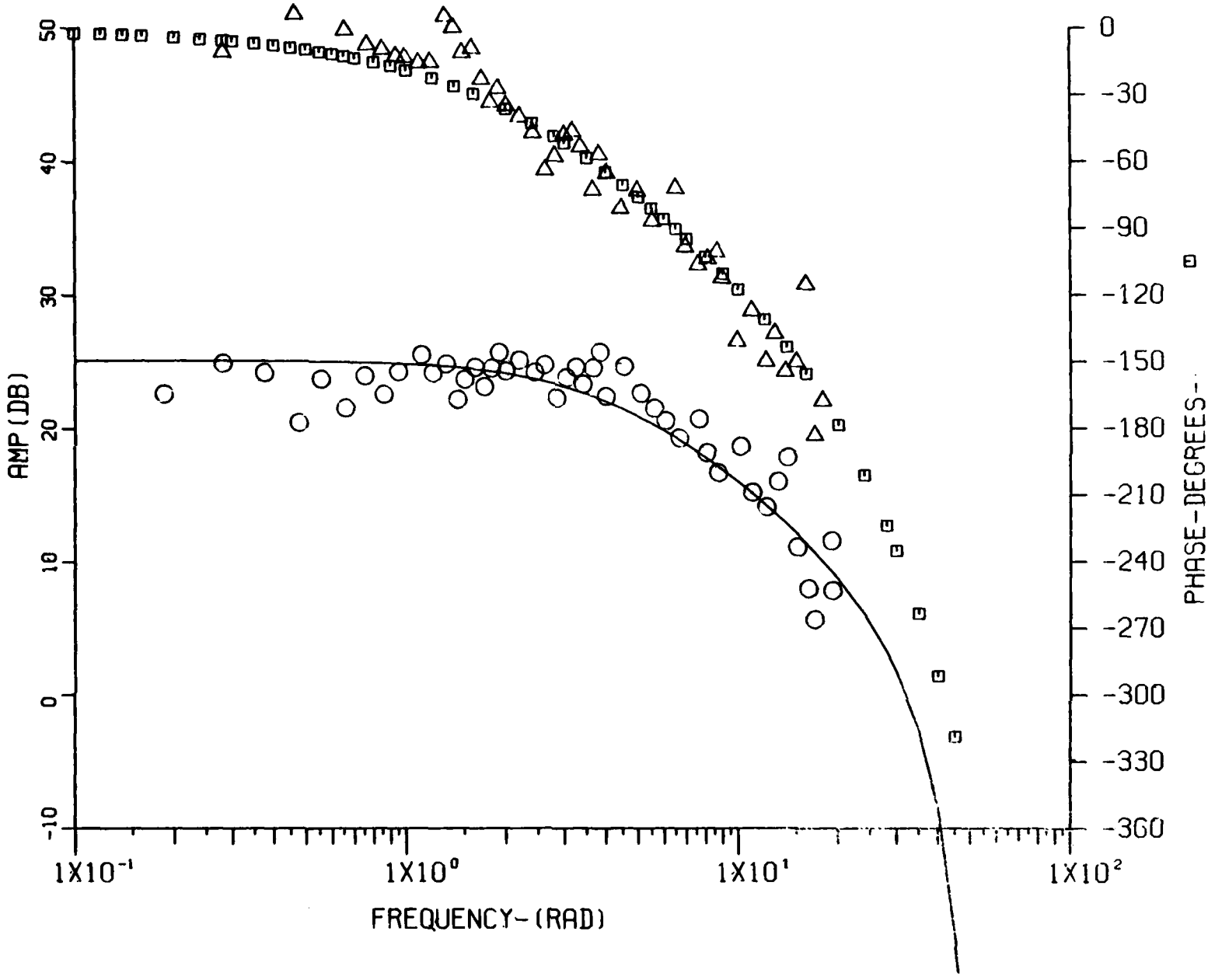


Figure H-5: LATHOS CONFIGURATION 3-3

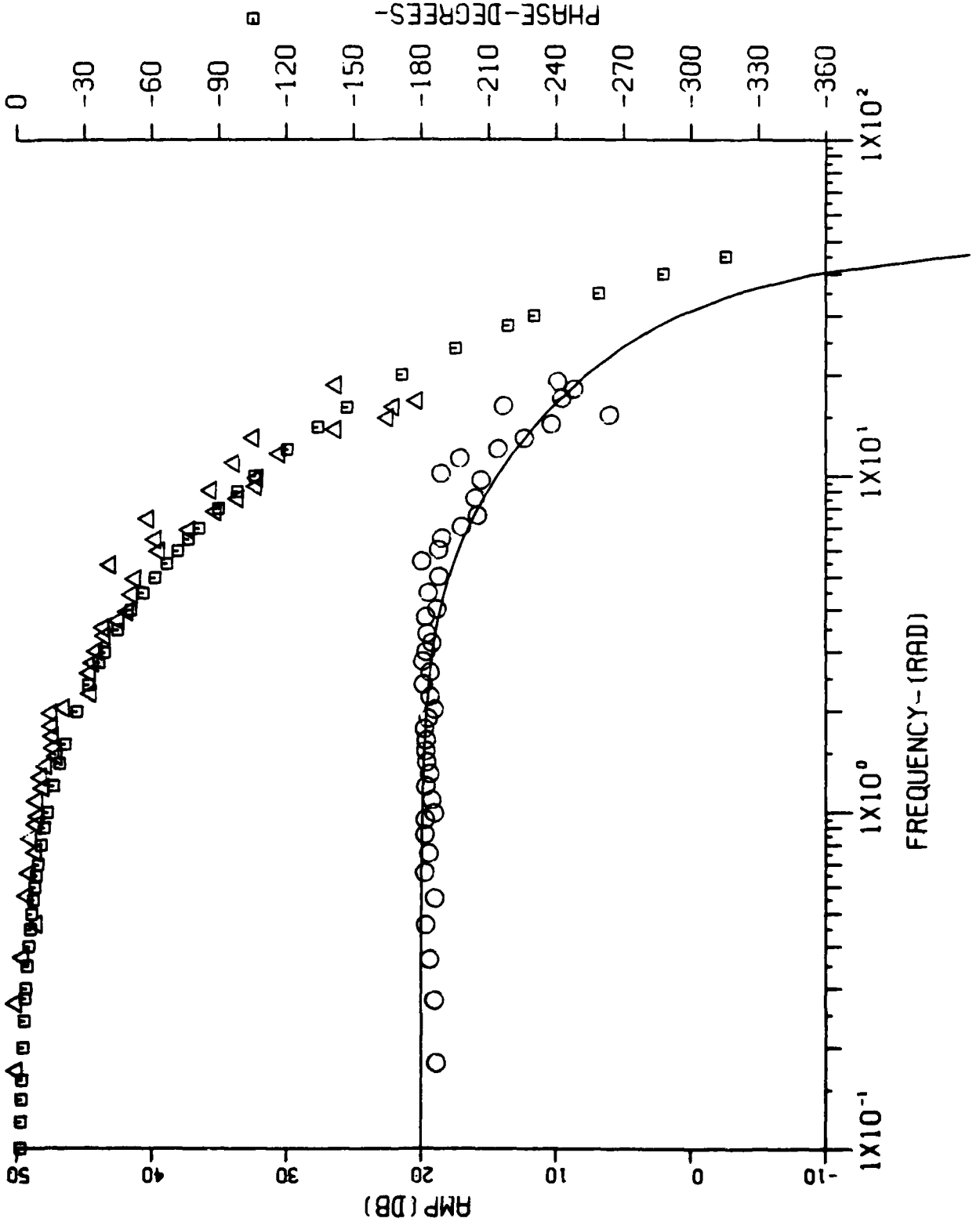


Figure H-6: LATHOS CONFIGURATION 5-2

APPENDIX I

NT-33A SIMULATION MECHANIZATION

This in-flight experiment was performed in the three-axis variable stability NT-33A aircraft, modified and operated by Calspan for the USAF. The desired control system dynamics were simulated by altering the NT-33A "fly-by-wire" control system with suitable electronic circuits. Aircraft dynamic characteristics for each simulation configuration were achieved by using the variable stability response feedback system in the NT-33A. A force command control system was used in the three control axes with the feel system characteristics of each held fixed throughout the experiment for a given flight phase (Figure I-1). The feel system dynamics were mechanized using an electrohydraulic servo with position and rate feedbacks to control the frequency and damping as well as the desired spring force gradient. Although available, no friction or breakout forces were included in the simulation.

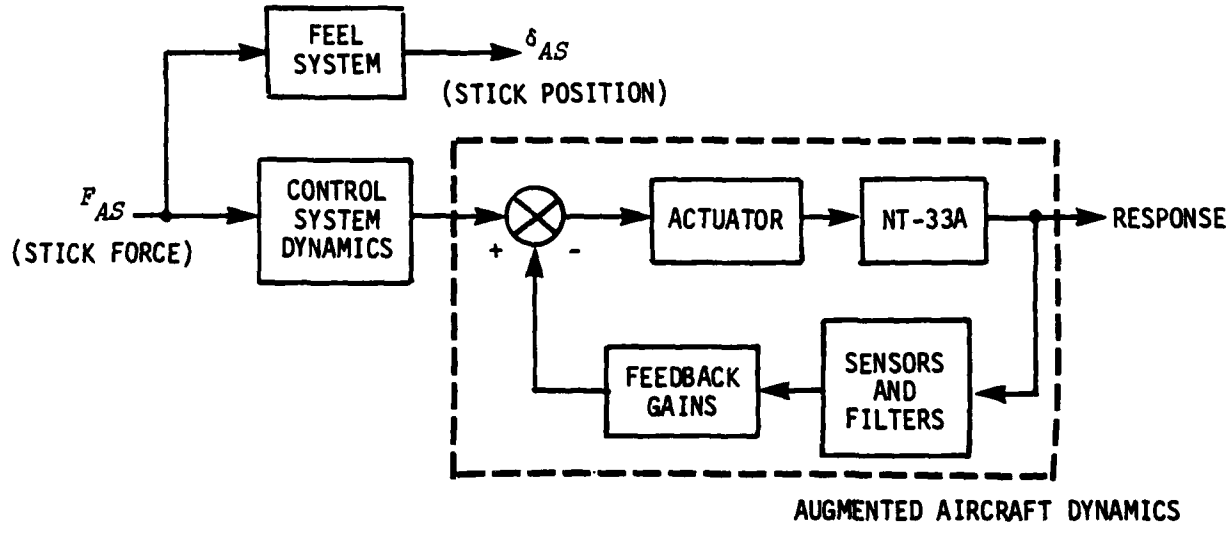


Figure I-1: SIMULATION MECHANIZATION

The simulated aircraft configuration characteristics are described in Appendix IV. Also described in Appendix IV are the calibration methods for achieving the desired augmented aircraft dynamics.

The desired augmented aircraft dynamics were achieved by feeding back the appropriate signals to the NT-33A control surface actuators with the proper feedback gains (Figure I-1). Closure of the feedback loops will cause the actuator roots to migrate somewhat, but because the roots are at very high frequency, this movement is not of consequence in the simulation and the actuator dynamics are assumed constant. The lateral feedback gains were scheduled as a function of tip tank fuel in the NT-33A because of its large contribution to roll and yaw inertia and also, the lateral unaugmented dynamics of the NT-33A. In this manner, a configuration's dynamics were kept approximately constant as fuel was depleted. Using the fuel remaining gain schedule, the augmented dynamics varied only to a maximum of 8%. This variation was taken into account in specifying the accuracy to which the lateral augmented aircraft dynamics were defined.

Standard feedbacks of aircraft angular rate, linear acceleration, and sideslip and angle of attack (measured from vanes) were used in mechanizing the augmented aircraft dynamics. The effects of filter and sensor dynamics in the feedback paths are minimal in the simulation. The sensors and associated filters are defined in Reference 11. Exceptions are outlined below.

The desired Dutch roll natural frequency and damping ratio of the augmented aircraft configuration was significantly greater than the unaugmented NT-33A. Special feedback circuits were required to obtain the desired Dutch roll characteristics without compromising the simulation fidelity. For the nominal augmented configurations in both flight phases, aerodynamic sideslip angle (β_{vane}), yaw rate, and washed-out yaw rate were fed back to the rudder. Although β_{vane} gain was scheduled with fuel remaining to maintain a constant augmented Dutch roll frequency, the yaw rate feedback gains were fixed. The Dutch-roll damping ratio, as a result, increased during the evaluations from 0.3 to 0.4 as the fuel remaining and inertia of the NT-33 decreased. The nominal value of ζ_{DR} ($\simeq 0.35$) was chosen accordingly.

The washed-out yaw rate feedback is:

$$\left(\frac{\delta_R}{r}\right)_{w.o.} = K_{r_{wo}} \left(\frac{s}{s+1}\right)$$

The heavily damped Dutch roll configurations, denoted by identifiers D1 and D2, were implemented by feeding back an approximate inertial $\dot{\beta}$. The approximate $\dot{\beta}$ term was calculated:

$$\dot{\beta}_I = \left\{ g/V \left[N_Y + \cos\theta \sin\phi \right] - r + p\alpha \right\} K_{\dot{\beta}}$$

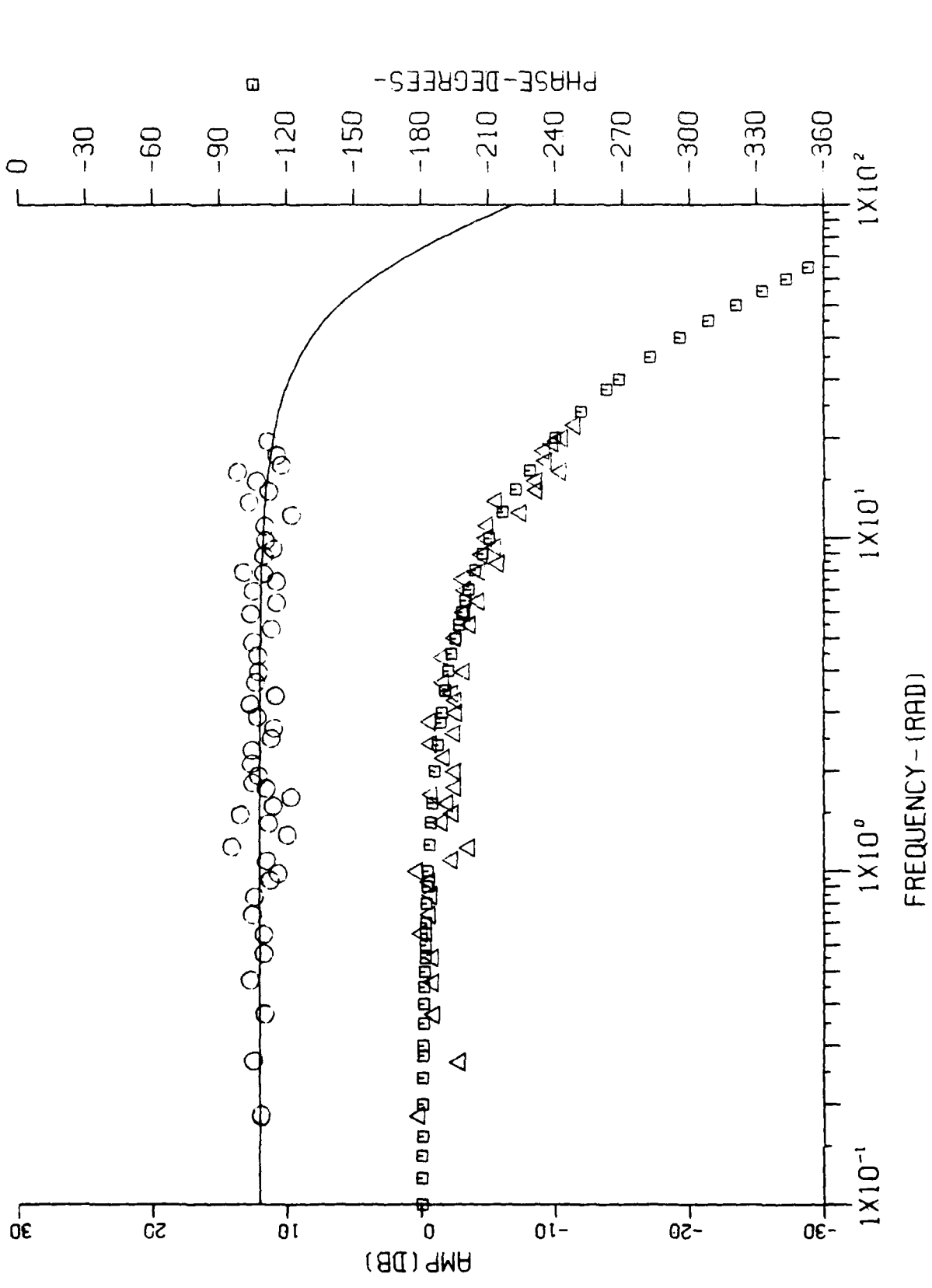


Figure H-7: LATHOS (δ_A/F_{AS})

APPENDIX J

DISPLAY EVALUATION FLIGHT TEST SYSTEM

The Display Evaluation Flight Test (DEFT) system includes equipment installed in the USAF NT-33A variable stability aircraft, and a ground-based integrated test bench. The aircraft installation includes a fully programmable Head-Up-Display and had growth capability to allow the future addition of head-down or helmet-mounted displays. The integrated test bench is installed in a large van. The test bench duplicates aircraft hardware and software, and includes facilities for programming, debugging, and analysis.

Display Format:

A conventional HUD format, shown in Figure J-1, was used during this flight test program. For the air-to-air tracking task, the flight path marker was locked in azimuth and elevation on the display and depressed below the aircraft flight path by less than one degree. The center of the flight path marker (forming an inverted "T") served as the aiming index (pipper). The flight path marker is approximately 10 mils in diameter.

Aircraft Installation (Figure J-2):

- HUD Optics: Front cockpit AVQ-7 HUD, identical to the unit installed in A-7D/E aircraft.

- Rear Cockpit Repeater: Cathode ray tube display repeater to allow rear cockpit pilot to monitor HUD.

- Programmable Display Generator: Digital computer which strokes alphanumerical characters and display symbols on the HUD. Characters and symbols are stored in a 4000 word memory.

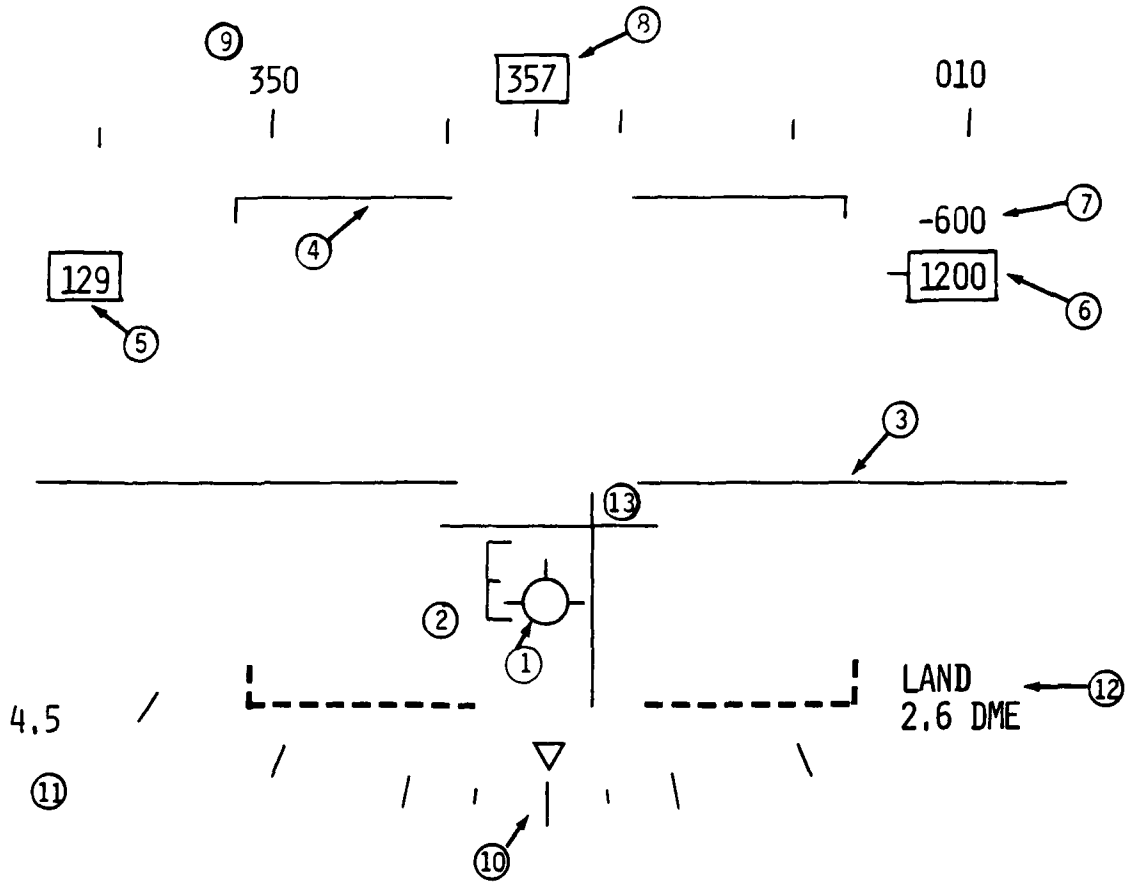
- General Purpose Computer: A 32,000 word digital computer which processes sensor and mode control data, and directs programmable display generator character stroking.

- Dual Tape Drives: Total of eight digital magnetic tape tracks. One track used to program the general purpose computer and the programmable display generator. Remaining seven tracks available for data recording.

- Mode Control Unit: Located in rear cockpit. Manual mode control and data insertion accomplished with pushbuttons. Interactive format control through menues displayed on rear cockpit repeater

- Declutter Switches: Two front cockpit switches allow limited front cockpit mode/format control.

- Sensors: Signals from various sensors conditioned by input/output units and then used by the general purpose computer. Sensors include



1. Flight path marker (also used as aiming index (pipper) when fixed on display for tracking tasks)
2. Angle of attack bracket (α less than command. α = command when bracket is aligned with flight path marker). *
3. Horizon line
4. Pitch ladder
5. Indicated airspeed
6. Barometric altitude
7. Vertical velocity
8. Magnetic heading
9. Heading Scale
10. Bank angle scale (30 deg. max.)
11. Angle of attack
12. Mode and range of touchdown *
13. ILS deviation bars *

* included only for landing tasks

Figure J-1: BASIC HEAD-UP-DISPLAY FORMAT

where $V = V_T$

$\alpha = \alpha_T$

$sin\ \phi = \phi$

and $cos\ \theta = 1.$

The constant values of airspeed and angle of attack for this experiment were:

Flight Phase Category A: $\alpha_T = 0.0^\circ$

$V_T = 550\ fps$

Flight Phase Category C: $\alpha_T = 5.5^\circ$

$V_T = 220\ fps$

This $\dot{\beta}_I$ feedback circuit produced nominal Dutch roll damping ratio values of $\zeta_{DR} \approx 0.8$ and $\zeta_{DR} \approx 0.6$ for flight phase Category A and C, respectively. Brief analyses were performed to ensure that the washed-out yaw rate and $\dot{\beta}_I$ feedbacks had minimal influence on the simulation fidelity and did not adversely compromise the configuration characteristics. Detailed analyses were, however, beyond the scope of this report. The information necessary to perform these analyses is provided but, based on our analyses, the effects that these feedbacks had on the simulation are negligible, except for the prescribed modification of the Dutch roll dynamics.

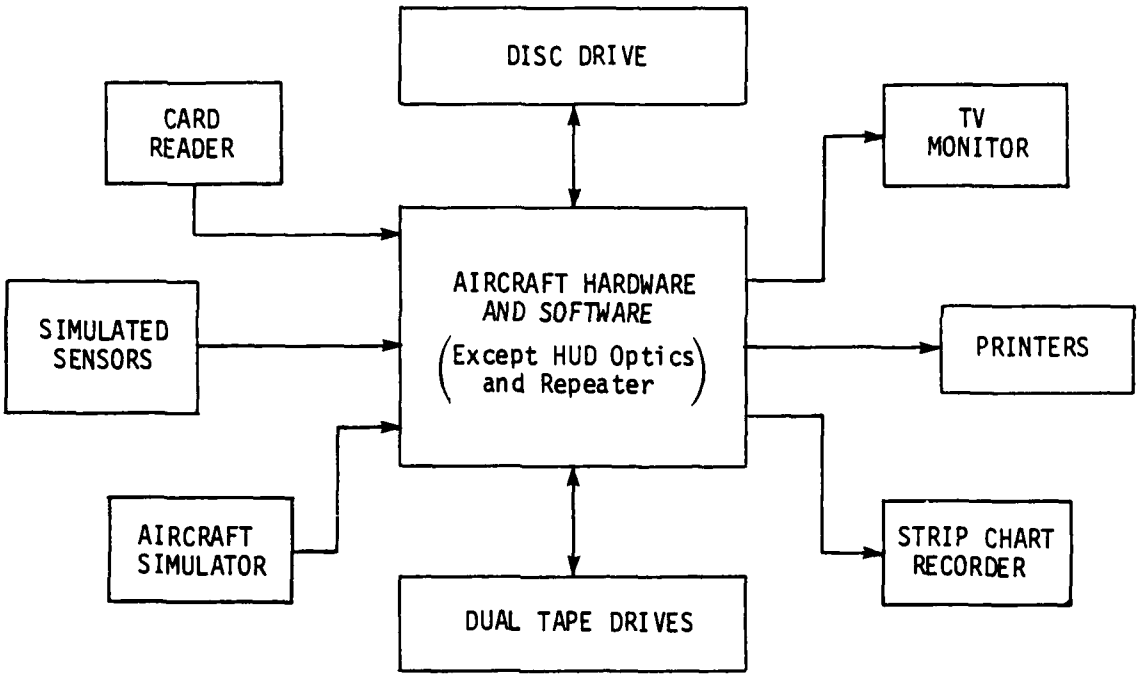


Figure J-3: DISPLAY EVALUATION FLIGHT TEST SYSTEM INTEGRATED TEST BENCH

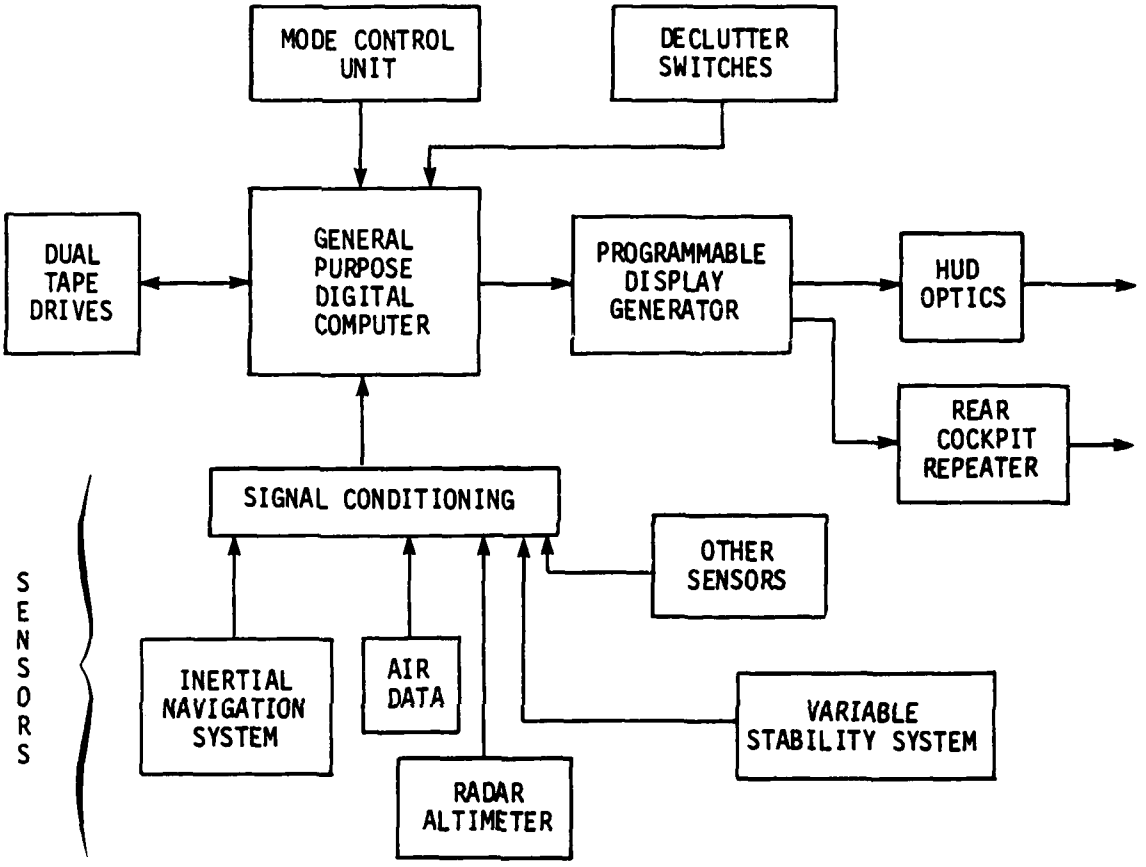


Figure J-2: DISPLAY EVALUATION FLIGHT TEST SYSTEM AIRCRAFT INSTALLATION

an inertial navigation system, radar altimeter, air data, and land based and ship based instrument landing system. Also, angle, angle rate, acceleration, force, and displacement signals are available from the variable stability system.

Integrated Test Bench (Figure J-3):

- Aircraft Hardware and Software: With the exception of the HUD optics and rear cockpit repeater, the aircraft installation is duplicated in the integrated test bench (a TV monitor is used for display).

- Input/Output/Storage Devices: 120 character line printer, 80 character teletype printer, disc system, card reader, strip chart recorder.

- Sensor Simulator: Adjustable signals simulating all appropriate sensors.

- Aircraft Simulator: Simple dynamic aircraft simulator, with control stick, for interactive program testing.

System Operation:

- Programming Phase: General purpose computer and programmable display generator programs are designed which use available sensor data to provide desired HUD formats. The integrated test bench is used for program preparation, de-bug, and storage.

- Data Entry Phase: Prior to each flight, the integrated test bench is used to produce a digital tape which contains the computer programs and other information peculiar to the upcoming flight (e.g., runway data, filter coefficients).

- Flight Phase: Flight tasks are performed using the HUD. Modes and formats are changed automatically by the general purpose computer, or manually through the mode control unit and declutter switches. Data is recorded on magnetic tape.

- Playback Phase: Digital tape records are played back on the HUD in flight and after landing.

- Analysis Phase: The integrated test bench is used to further review taped records. Hard copies or strip recordings of in-flight data may be produced.

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